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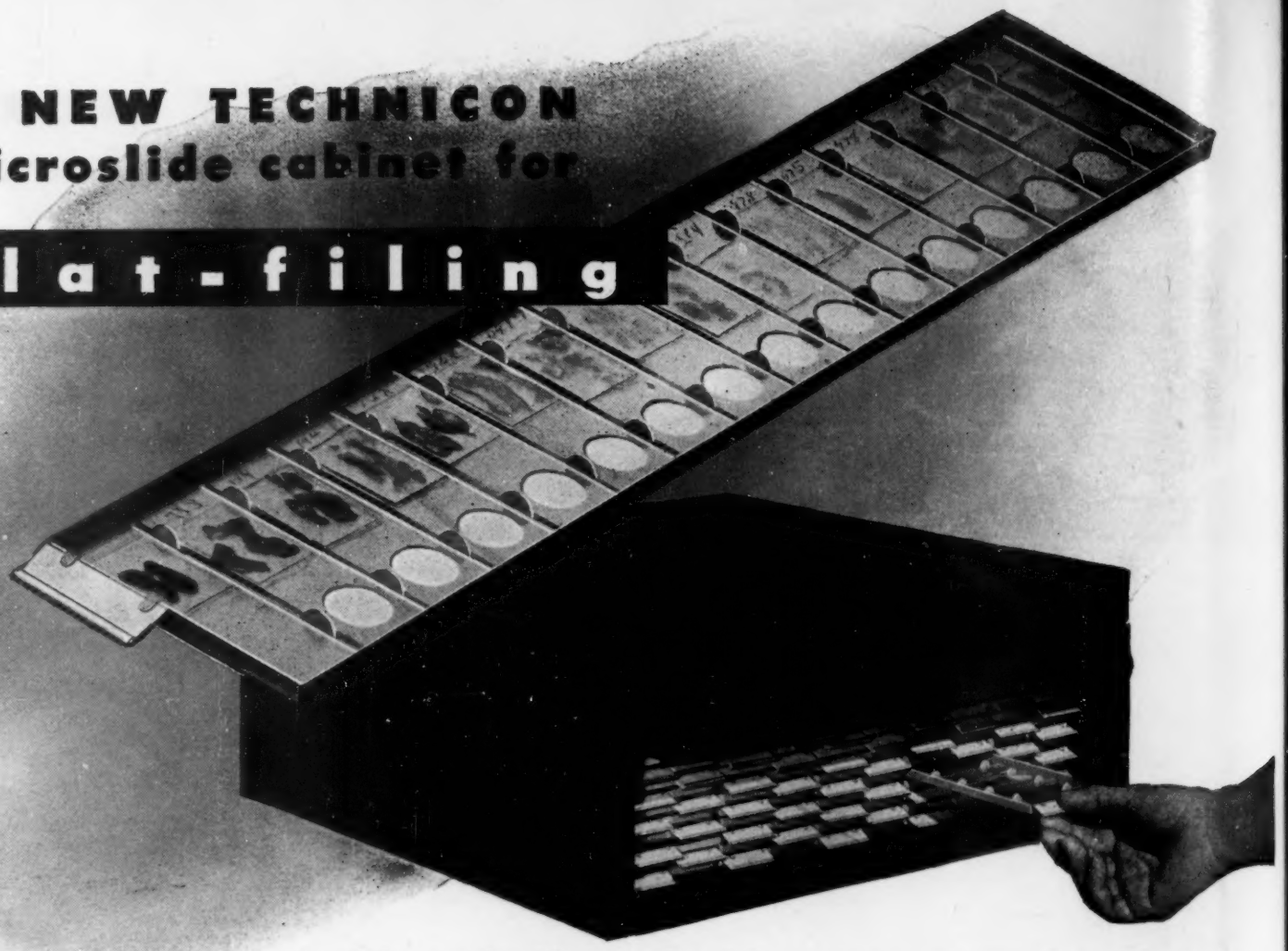

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West Washington Square **Philadelphia 5**

Science

Mildred Atwood, Acting Editor — F. A. Moulton, Advertising Manager

Publications Committee
Farrington Daniels, John E. Flynn, Kirtley F. Mather, Walter R. Miles, Malcolm H. Soule, Steven M. Spencer

Vol. 108 No. 2799 Friday, August 20, 1948

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Science, a weekly journal, is published each Friday by the American Association for the Advancement of Science at The Business Press, Incorporated, N. Queen St. and McGovern Ave., Lancaster, Pa. Founded in 1880, it has been since 1900 the official publication of the AAAS. Editorial and Advertising Offices, 1515 Massachusetts Avenue, N.W., Washington 5, D. C. Telephone, EXecutive 6060 or 6061. Cable address, SCIMAG, Washington, D. C. Entered as second-class matter at the Post Office at Lancaster, Pa., January 13, 1948, under the Act of March 3, 1879. Acceptance for mailing at the special rate postage provided for in the Act of February 28, 1925, embodied in paragraph 4, Sec. 538, P. L. and R., authorized January 13, 1948.

Articles offered for publication should be sent to the Editor. The AAAS assumes no responsibility for the opinions expressed by contributors. Membership correspondence for the AAAS should be sent to the Administrative Secretary.

Annual subscription, $7.50; single copies, $.25; foreign postage (outside the Pan-American Union), $1.00 extra; Canadian postage, $.50 extra. Remittances and orders for subscription and single copies should be sent to the Circulation Department, AAAS, North Queen Street and McGovern Avenue, Lancaster, Pennsylvania, and 1515 Massachusetts Avenue, N.W., Washington 5, D. C. Claims for missing numbers will not be allowed if received more than 60 days from date of issue. No claims allowed from subscribers in Central Europe, Asia, or the Pacific Islands other than Hawaii or because of failure to notify the Circulation Department of a change of address or because copy is missing from the files.

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Contemporary Neutron Physics

Arthur H. Snell
Oak Ridge National Laboratory, Oak Ridge, Tennessee

"SUCH AN ATOM WOULD HAVE VERY NOVEL PROPERTIES. Its external field would be practically zero, except very close to the nucleus, and in consequence it would be able to move freely through matter. Its presence would probably be difficult to detect with the spectroscope, and it may be impossible to contain it in a sealed vessel. On the other hand, it should enter readily into the structure of atoms. . . ." Such was Rutherford's prediction (*21*) of the properties of atoms with zero nuclear charge, 12 years before they were discovered and became generally known as neutrons. In the 1930s they rapidly established their reputation as fascinating experimental subjects, but were little known outside of

FIG. 1. Building housing the reactor of the National Research Council of Canada at Chalk River, Ontario.

nuclear physics laboratories. The closing days of the war revealed them dramatically as the business of men at large and the basis of big engineering projects (Fig. 1; courtesy National Film Board), for they were disclosed as the dynamic agents of nuclear reactors and atomic bombs. Yet this emergence into the headlines has not detracted from their continuing fascination as laboratory subjects; much is still being learned about their interaction with matter and about their properties as elementary particles.

NEUTRON CROSS SECTIONS; NEUTRON "SPECTROMETRY"

The biggest single subject in neutron physics is the study of the nuclear cross sections for various processes and their variation with the neutron energy. A "cross section" in this sense is the effective target size which the nucleus presents to the approaching neutron; the latter is considered to be a point. If all cross sections were just the geometrical sizes of the nuclei, their measurement would be dull indeed. Actually, this is far from the case, for resonance and other effects introduce such enormous variations that the study becomes very colorful. The slow neutron capture cross section of Gadolinium 157, for example, is 4×10^4 times larger than its geometrical cross section. On the other hand, Nitrogen 15 has a capture cross section less than 10^{-7} of its geometrical cross section—which is merely a technical way of saying that it stubbornly refuses to capture slow neutrons. The Gadolinium 157 cross section is at least 10^{12} times larger than that of Nitrogen 15! This astonishing range of magnitude has important practical consequences in such matters as nuclear reactor design. Here a new scale of values of structural materials has sprung up; if a suggestion is made as to a new substance for use as part of a reactor, the first question asked is not "What is the tensile strength?" or "What is the cost?" but rather "What is the cross section?" Clearly, the cross sections for various processes are fundamental to any quantitative treatment of the interaction of neutrons with matter. They are also the most frequent meeting ground of experiment with nuclear theory.

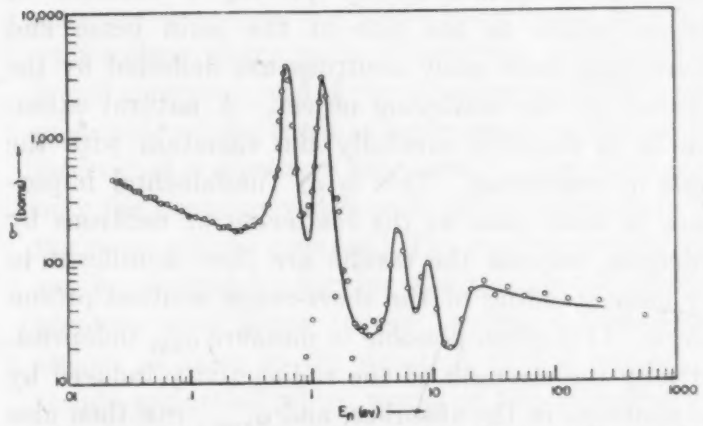


FIG. 2. The slow neutron absorption spectrum of Iridium as measured by the Columbia University neutron spectrometer group (from H. H. Goldsmith, *et al. Rev. mod. Phys.*, 1947, **19**, 291). The rise to the left is tpical of the 1/v part of the spectrum, and the peaks are neutron capture resonances.

The variability in absolute magnitude of the slow neutron capture cross sections is accompanied by unpredictable fluctuations in the cross sections of individual nuclear species as the energy of the incident neutrons is changed (Fig. 2). Characteristically, the

absorption spectrum consists of two parts: (1) In the low-energy range (perhaps up to a few electron volts) the capture cross section is inversely proportional to the neutron's velocity v (*i.e.* directly proportional to the time spent by the neutron near the nucleus), while (2) above the 1/v region there are a number of irregularly spaced peaks, some of which may be astonishingly high. There are exceptions to this general picture. In some cases the peaks may be missing so that the 1/v region is visible to higher energies, and in other cases the peaks may invade the 1/v region to below thermal energies. The peaks are accounted for in the Breit-Wigner theory (1936) as maxima which occur when the energy of the incident neutron is such as to place it in resonance with an energy level in the compound nucleus formed upon capture. As such, the neutron resonances give us information about the spacings and widths of nuclear energy levels.

A great deal of cross-section work is being done with simple transmission experiments or elaborations thereof. A neutron detector is placed some distance from a source, and an absorber is placed between the two. The attenuation of the neutron beam reaching the detector is then proportional to $e^{-Nx\sigma}$, where N is the number of atomic nuclei per cm^3 of absorber, x is the thickness in cm, and σ is the nuclear cross section which is effective for removing neutrons from the beam. This removal can be accomplished either by direct absorption of the neutrons into the nuclei of the absorber or by nuclear collisions which result in the scattering of the neutrons from the beam. The cross section can accordingly be divided into two parts: $\sigma = \sigma_{abs} + \sigma_{scatt}$. σ_{scatt} can in principle be measured independently by placing a detector at various points to the side of the main beam and determining how many neutrons are deflected by the presence of the scattering object. A natural extension is to measure carefully the variation with the angle of scattering. This is of fundamental importance in such cases as the scattering of neutrons by hydrogen, because the results are then significant to our understanding of the short-range neutron-proton forces. It is often possible to measure σ_{abs} independently by the strength of the radioactivity induced by the neutrons in the absorber, and σ_{scatt} can then also be determined by difference: $\sigma_{scatt} = \sigma - \sigma_{abs}$.

This type of experimentation is clearly very simple in principle. Actually, it is the desire to know the variations of σ with neutron energy which introduces the complications and calls for experimental ingenuity. The problem of making a source which emits neutrons of a single energy is being met in a variety of ways. One of the simplest is the use of photoneutron sources. It happens that two materials, deuterium and beryllium, can be persuaded to release neutrons by the action of gamma rays of quite modest energy; in fact, the (γ,n) threshold of beryllium is 1.63 Mev, and that of deuterium is 2.18 Mev. It also happens that nuclear reactors and cyclotrons can make a dozen or so radioactive substances which emit gamma rays with energies greater than 1.63 Mev. For example, one can place sodium in the nuclear reactor overnight and in the morning have a powerful source of 2.76 Mev gamma rays from Sodium 24. If this radioactive sample is then placed in a lump of beryllium, neutrons will emerge, and they will all have an energy of $2.76 - 1.63 = 1.13$ Mev (provided the beryllium lump is not large enough to degrade the gamma rays or to slow down an appreciable number of the neutrons by nuclear collisions). Likewise, if the sodium is placed in heavy water, neutrons with an energy of 0.58 Mev will be produced. In either case, transmission, absorption, and scattering experiments can be made in any desired substances and values of σ_{abs}, σ_{scatt}, and σ obtained for neutrons of these energies. A survey of cross sections measured in this way has recently been made at the Argonne National Laboratory (*10*). Inasmuch as nature provides only a limited number of combinations of materials which can make photoneutron sources of this kind, the results to be obtained can only be rather spotty in terms of a study of the variation of the σ's with energy.

A classical source of monoenergetic fast neutrons has been the so-called "D-D" source, in which deuterium is bombarded with deuterons in a high-voltage machine. The reaction concerned is

$$_1D^2 + {}_1D^2 \rightarrow {}_2He^3 + {}_0n^1 + 3.31 \text{ Mev.}$$

Because of momentum conservation effects in the target, the neutrons will come off with energies depending on their angle with the primary deuteron beam. Together with variation of the beam voltage this sensitivity to angle can be used as a means of varying the neutron energy. Neutrons below about 1.5 Mev are, however, unobtainable. Partly because of this handicap, it has been more usual recently to use the Li(p,n) reaction in electrostatic generators as a source of neutrons of moderate and controllable energy. The reaction is

$$Li^6 + p \rightarrow Be^7 + n - 1.62 \text{ Mev.}$$

Below 1.62 Mev no neutrons are observed. As the energy of the protons is increased above the threshold neutrons are emitted and their energy depends upon the voltage and upon the angle of emission from the target relative to the incident proton beam. The energy spread of the neutrons depends upon the thickness of the lithium target and upon the steadiness of the voltage; therefore, the targets usually are very thin lithium films, vacuum-evaporated *in situ* upon a heavy metal backing, and the voltage is stabilized with

high precision by automatic devices. This kind of monokinetic neutron source has been the basis of a number of important light-element cross-section studies made at Los Alamos. The energy range covered is approximately from 0.05 to several Mev.

The 184-inch cyclotron at Berkeley has turned out to be a unique source of very fast neutrons, and it is ideally adapted for cross-section measurements in the region of 100 Mev. The neutrons emerge from the target in a well-defined beam, the origin of which is in itself interesting (*15*). Let us consider what happens when a high-speed (190-Mev) deuteron passes near a target nucleus. The neutron and the proton have internal motion about their common center of gravity in the deuteron. If the proton should happen to be closer to the target nucleus at the moment of passing, it is possible that it will stick in the nucleus. The neutron will then carry on with a velocity and direction determined by the vectorial addition of its motion in the deuteron and its motion in the cyclotron beam. At 190 Mev, the latter is by far predominant. The neutron beam therefore shoots out in the direction that the cyclotron beam had when it struck the target. It has an angular spread of a few degrees, and an energy spread of about 40 Mev which arises from the fact that the neutron's velocity internal to the deuteron could either add to or subtract from the velocity in the cyclotron beam. The neutron beam passes through the vacuum chamber wall and is conducted through a pipe set in the thick concrete shield surrounding the cyclotron, and it is thus available for experimentation in the surrounding laboratory space. Of course, a similar beam of protons is simultaneously made when the neutrons, instead of the protons, are stripped from the deuterons by the target nuclei, but it is swept aside because the protons, being charged, are still subject to the forces of the cyclotron's magnetic field.

One of the studies made with this neutron beam was concerned with the variation of σ_{scatt} with the atomic weight A of the scatterer. Earlier, a similar study (*22*), made with 20-Mev neutrons from the old Harvard cyclotron, had shown that σ_{scatt} was proportional to $A^{2/3}$. The σ_{scatt} so measured was, in fact, a good measure of the geometrical cross section of the nucleus; this is one way to measure the size of nuclei. The results from the Berkeley survey with 90-Mev neutrons (*7*) showed a similar smooth increase of σ_{scatt} with A, but the σ_{scatt}'s measured at Berkeley were all *smaller* than those measured at Harvard. This is interpreted as evidence of a partial transparency of nuclear matter to the neutrons of higher energy. The wave length of the 90-Mev neutrons (3×10^{-13} cm) is comparable with the nuclear dimensions, and the probability exists that the neutron can slip through the nucleus without being deflected. Apparently, even nuclear matter, by far the densest known, has some Swiss-cheese characteristics when viewed by appropriate means.

Let us jump now from the very fast neutron field to the slow neutron field. The latter is generally taken to cover the energy range below about 100 ev. Here we find that the experimental tools are again different and that the data are much more complete. One method of attack is that of crystal spectrometry. Since this has itself been the subject of a recent article in *Science* (*23*), we shall simply state here that in the energy range of a few electron volts the neutrons have wave lengths comparable to the lattice spacings of atoms in crystals, and therefore they exhibit Bragg reflection just as do X-rays and electrons. Thus, if a narrow beam of slow neutrons of mixed energies is allowed to fall upon a crystal at an appropriate small angle, at another appropriate small angle there will be found a beam of monokinetic neutrons coming from the crystal. One therefore makes transmission measurements at various angular settings in order to cover the available energy range. Since this type of work practically demands the intense, steady, slow neutron beams which are obtainable only from nuclear reactors, it is in progress mainly at the Argonne and Oak Ridge National Laboratories.

By far the greater part of the slow neutron spectrometry has been done by means of the "time-of-flight" method. This method is based upon the fact that it takes quite a respectable time (e.g. 1 millisecond) for a slow neutron to cross a room. If a neutron source on one side of the room is made to emit a short, sharp pulse of neutrons (of unavoidably mixed energies), and if the detecting apparatus on the other side of the room is made sensitive for an equal interval *at a relatively long time, t, later,* then clearly only the neutrons which took about t seconds to cross the room will be counted. The neutron energy range can be covered by varying t, although the resolution becomes poor above 100 ev because t then becomes almost as short as the duration of the pulses. One simple apparatus which works on this principle is the velocity selector at the Argonne Laboratory (*8*). A cadmium shutter rotates in a beam of slow neutrons emerging from a nuclear reactor. Since the cadmium absorbs slow neutrons completely, a chopped beam results. A mirror mounted on the rotating mechanism flashes a light signal to the detecting equipment, which is then electronically sensitized for the appropriate interval. The time, t, is determined by the angular displacement of the mirror relative to the cadmium on the rotor. Mechanical choppers of this

kind have their main usefulness in the energy range below about 0.1 ev.

The time-of-flight measurements have come to full flower in connection with cyclotrons. Cornell and Los Alamos have contributed in the past, but the most consistent and sustained efforts have been made at Columbia (*20*). In an important series of papers in the *Physical Review,* the Columbia group have described measurements of the neutron cross sections of nearly all of the elements in the energy range 0.015–1,000 ev. Fig. 2 is a reproduction of one of their curves which may be considered typical.

The reader may have noticed that in our discussion we have left an energy gap covering, roughly, the region 1,000–50,000 ev. This region has been difficult to deal with experimentally, partly because detectors become relatively insensitive and partly because of the difficulties of finding suitable sources. The gap is now being closed. Refinements in the Li(p,n) technique are reducing it from the high-energy side, and important improvements in the Columbia apparatus are closing it from the low-energy side. It is true that the resolution obtainable in this difficult region remains rather poor, but the results are, nevertheless, significant. A pretty example of a fairly complete cross-section curve is that of aluminum, published in a recent compilation of cross-section data which appeared in the *Reviews of Modern Physics* (*11*). This curve covers the energy range from 0.001 to 1.0 Mev and shows a group of prominent resonances in the hundreds-of-kilovolts region.

Scattering Resonances

We have spoken of the peaks in the cross-section curves (Fig. 2) as being almost entirely due to absorption. The Breit-Wigner theory recognized, however, that they might be accompanied by especially prominent scattering; in fact, some of them might be almost entirely due to scattering, particularly in the hundreds- to thousands-of-electron-volts region. The existence of these scattering resonances has recently been experimentally demonstrated at the University of Illinois and at the Argonne Laboratory. In the experiments at the Argonne Laboratory a number of elements have been surveyed. Cobalt is typical of those which gave a positive result. A neutron beam from the reactor was passed axially down an evacuated tube which formed the inner wall of a double-walled cylindrical counter, the annular space of which was filled with BF_3 gas. Ordinarily there would be no counts registered in the BF_3 because there would be nothing to deflect neutrons from the beam into the sensitive region of the counter. However, when a thin cobalt foil was placed in the middle of the apparatus, the whole assembly became a detector sensitive to neutrons which are scattered by cobalt. Another cobalt foil was then placed in the neutron beam some distance ahead of the counter, and the transmission of this foil was measured as it appeared to this very specialized detector. The effective σ thus found was much higher than it would have been if the foil in the detector had been something other than cobalt or if the foil in the detector absorbed, rather than scattered, the neutrons falling upon it. The demonstration of a scattering resonance was therefore clear. The average neutron energy in the primary beam was varied somewhat by interposing different thicknesses of boron in order to absorb different proportions of the slow neutron component, and in this way the scattering was identified as arising from a resonance at 115 ev, previously found by the Columbia cyclotron group.

A similar result was obtained for a 300-ev resonance in manganese, and a survey of elements gave indications of resonance scattering from a number of medium-light elements—predominantly from isotopes of odd mass number (*12*).

Slowing Down and Diffusion of Neutrons

The nuclear reactions which give rise to free neutrons nearly always produce them with energies of the order of millions of electron volts. Since many of their most striking properties appear when they have energies of hundredths of one electron volt, the mechanism of slowing them down becomes one of importance. The slowing down is accomplished by allowing them to pass through matter where they lose energy by nuclear collision processes. If the nuclei are heavy, there is energy loss by inelastic collisions, *i.e.* some of the neutrons' kinetic energy is used to excite the nuclei to states which they later leave by means of gamma-ray emission. For light nuclei the energy loss arises mainly from elastic or billiard-ball collisions.

Application of the ordinary laws of conservation of momentum and energy to the elastic collisions shows that, on the average, the ratio of the energy of a neutron after impact to its original energy is a constant depending only upon the mass of the nucleus struck; in other words, the percentage loss in energy per impact is constant or, again, the mean logarithmic energy loss ξ is a characteristic of the medium. For example, for graphite, $\xi = 0.16$, and it follows that it takes about 110 collisions to slow a neutron from 10^6 ev down to 1/40 ev. In hydrogen (by far the most efficient slowing-down agent), $\xi = 1$, and 17 collisions suffice, on the average, to give the same energy reduction.

After neutrons are slowed down in a medium they diffuse around until they are captured by nuclei or

escape from the boundaries. Neutron diffusion theory gives the density distribution of the neutrons in the medium, and direct comparison with experiment is easy. In its formulation, the diffusion theory is strongly reminiscent of classical heat-flow theory, with its sources and sinks and solutions of second-order partial differential equations through Fourier series, and its application of physical boundary conditions in the evaluation of the mathematical arbitrary constants. A typical solution is that of a rectangular parallelepiped with a source uniformly distributed over the end; in this case the neutron distribution some distance from the source plane is a negative exponential along the axis away from the source, and a cosine in the two transverse directions, with the maximum on the axis.

Present research lies mainly along the direction of introducing refinements in the theory and in its comparison with experiment. The substitution of "transport theory" for the older, less exact theories is an example. Transport theory takes into account the fact that for light elements there is a persistence of motion in the forward direction following elastic scattering collisions. On the experimental side, we may cite a current diffusion experiment at Oak Ridge in which the slowing-down theories are being tested with a photoneutron source buried in graphite. Such an arrangement lends itself to easy calculation, for the neutrons are initially monokinetic and the source is essentially a point.

Magnetic Properties of Neutrons; Neutron Polarization

Despite its lack of electric charge, the neutron has been found to have a magnetic moment. The measurement of this moment has been the subject of some rather elegant experimentation, but we shall forego a description of that in order to discuss the field of investigation which is opened by the mere *existence* of the moment. The point is that the magnetic moment gives us a grip upon neutrons whereby their orientation in space can be controlled. Consider a beam of slow neutrons passing through a block of iron. Their spins, and therefore their magnetic moments, will be randomly oriented in space, as also will be the magnetic moments of the iron atoms which they encounter. There will, however, be some interaction, and this results in some scattering of the neutrons. It will be noted that this is not a nuclear effect; the magnetic moment of the iron atoms is electronic in origin, and the magnetic forces between iron atoms and neutrons are much weaker, but of longer range, than the forces involved in scattering by direct nuclear collision. Anyway, the next step is to suppose that current is turned on somewhere in a coil, and the iron block becomes magnetized within 0.1% of saturation. The magnetic domains in the iron come to attention and line up with their moments co-directional in the field. The neutrons also straighten around so that their spins are either parallel or antiparallel with the field. There is now some coherency in the magnetically scattered waves. The interference of these waves with those arising from the purely nuclear scattering formed the basis of a prediction (1936) of an observable selective scattering effect. The prediction, which has been amply confirmed by experiment, was that those neutrons whose moments are aligned parallel to the imposed field will have an effective cross section $(\sigma_o - p)$ for scattering which is appreciably smaller than the cross section σ_o, which holds in the absence of the magnetic field. Such neutrons accordingly will be preferentially transmitted through the iron block. Simultaneously, the neutrons which had their moments aligned antiparallel with the imposed field will be scattered *more* efficiently than they were before the iron was magnetized (cross section: $(\sigma_o + p)$; consequently, the transmitted beam will be depleted in these neutrons. Because of the exponential character of the attenuation of the beam, these two effects do not exactly counterbalance; there is a net increase in the intensity of the total transmitted beam when the iron becomes magnetized. The percentage increase is called the "single transmission effect"; it is easily observed, and its magnitude is a measure of the degree of polarization in the beam of transmitted neutrons.

In the older work, the single transmission effect amounted to a few per cent, but it has recently been shown at the Argonne Laboratory (*16*) that the modern, powerful slow-neutron sources, plus some refinements in technique, permit the use of iron blocks up to 9 cm thick, with resultant single transmission effects of 100%. In such a beam, about 80% of the neutrons have their moments lined up parallel with the magnetic field and 20% antiparallel. Of course, this degree of polarization is purchased at the cost of a large reduction in intensity. The value found for the magnetic scattering cross section, p, is 3.15 barns.[1] With σ_0 equal to only 11 barns by itself, it is clear that the influence of the magnetic field upon the scattering is quite considerable.

What one would *like* to do with these polarized neutrons is to direct them against nuclei which are themselves lined up in space, and so measure the effects of the spin-dependent forces upon scattering, capture, fission, etc. It is the difficulty of lining up the target nuclei, rather than the neutrons, which at present is retarding the start of this kind of work. Meanwhile, the polarized neutrons are finding other

[1] One "barn" = 10^{-24} cm^2.

fields of usefulness. It turns out, for example, that the depolarization caused in a beam of such neutrons by a passage through a thin sheet of steel is related to the size of the microcrystals in the steel. Thus, if two magnets are set up in a polarizer-analyzer combination, the thin sheet can be placed between them and the depolarization can be measured (*5*). Thus, the relationship between metallurgical treatment and microcrystal sizes in steel can be evaluated by a new method. The future will probably see a broadening use of neutrons in studying many such nonnuclear properties of matter.

Search for Specific Interaction between Neutrons and Electrons

In the last section we discussed some of the consequences of the magnetic interaction between neutrons and atomic electrons, in so far as the influence upon scattering was concerned. Two recent experiments (*9, 13*) have been carried through in search for a new kind of electron-neutron interaction *independent* of spins and magnetic moments. Since the underlying concepts are interesting, we shall briefly describe one of the experiments (*9*) here.

According to the provisional probings of current meson theory, neutrons are not always solidly packed, neutral elementary particles. They may oscillate very rapidly between such a state and a state consisting of a proton with a negative meson about 10^{-13} cm away; in fact, they may spend as much as 20% of the time in the latter state. If this were the case, on a time-average basis there would be a net electric field very close to the neutron. According to the following reasoning, this might be observable as a slight asymmetry in the scattering of slow neutrons: the nuclear scattering is spherically symmetric in the center of gravity system because the scattering object is small compared with the wave length of the incident neutrons (about 10^{-8} cm). The atomic electrons, on the other hand, are arranged over distances comparable to the wave length of the incident neutrons, and if they *could* interact with the neutrons, they would produce an asymmetric scattering. The effect to be observed would arise from the interference of the two kinds of waves. The asymmetry would persist and, if found, would be indicative of the existence of a neutron-electron force field. Only a small effect would be expected, but there was always the possibility that the present formulation of the meson theory might have led to an underestimate.

In the experiment, xenon gas was chosen as the scatterer because (1) its closed electronic shell structure insures the absence of magnetic scattering, and (2) its monatomic gaseous nature insures the absence of any scattering arising from arrayed atoms. A beam of slow neutrons was directed through a vessel containing the xenon, and two counters were set up in order to detect neutrons scattered, respectively, at 45° and 135° with respect to the direction of the beam. Background counting rates were determined by freezing out the xenon. After the application of corrections to a series of observations, the net relative difference in the counting rates in the two directions turned out to be -0.0005 ± 0.0085. Apparently, the electron-neutron forces do not show up like a ton of bricks. In the cautious words of the experimenters: ". . . no interaction of an order of magnitude larger than that predicted by the meson theory exists between neutron and electron."

Delayed Neutrons

Another aspect of neutron physics which is arousing current interest is the phenomenon of delayed neutron emission. Originally discovered in connection with uranium fission, the delayed neutrons are the result of special circumstances in beta radioactivity. A highly beta-unstable nucleus may, after emission of its beta-particle, remain in a state of considerable excitation. Ordinarily this energy appears as gamma radiation accompanying the beta decay. However, it may happen that the excitation is greater than the energy corresponding to the binding of a neutron in the residual nucleus. If this occurs, a neutron is emitted in preference to gamma radiation. Consequently, we have the appearance of "neutron-emitting radioactivity" with half-lives and chemical behavior identical with those of the preceding beta transitions. The fission product nuclei, Bromine 87 and Iodine 137, have been identified as those responsible for two delayed neutron activities, with half-lives of 55 and 22 sec, respectively. Recent developments in the laboratory of the large cyclotron in California have shown that an additional nucleus, Nitrogen 17, producible by bombardment with 190-Mev deuterons, is a delayed neutron emitter (*4*). The half-life is 4.4 sec. The half-lives of delayed neutron activities are characteristically short, because of the implied high beta instability of the parent nuclei.

The identification of the fission-product emitters, Bromine 87 and Iodine 137, has a little story associated with it which is interesting because the identifications tie in very neatly with some recent ideas in nuclear structure. The initial tentative identifications were made in the face of rather serious theoretical objections. These objections arose from the fact that these isotopes are both very close to stability. It should be noted that after beta emission, Bromine 87

comes Krypton 87 and Iodine 137 becomes Xenon 137; it is the Krypton 87 and the Xenon 137 nuclei which actually emit the delayed neutrons. Yet the isotopes Krypton 86 and Xenon 136, *just one mass unit below,* are completely stable. It would have been much more probable that the delayed-neutron emitting isotopes should have been, say, Krypton 91 and Xenon 141, both because the beta instability would be greater and because the neutron-binding energy would be smaller. In spite of these considerations, the first identifications were tentatively made (*24*), and these were later confirmed (*26*). Now it has recently been observed (*19*) that nuclei which contain, respectively, 50 or 82 neutrons are especially stable. The evidence comes from several directions; for example, more different stable isotopes (Xenon 136 through Samarium 144) contain 82 neutrons than any other single number of neutrons, and the second in rank are the stable nuclei which contain 50 neutrons (Krypton 86 through Molybdenum 92). Also, the natural abundances of the 50- and 82-neutron stable isotopes are exceptionally high in comparison with others in like situations with regard to the main line of stability in the isotope chart. Finally, the capture cross sections of the 50- and 82-neutron stable isotopes for both slow and fast neutrons are abnormally low compared with those of their neighbors. Apparently, something has become satiated in these nuclei; another neutron is definitely *non grata.*

Now we observe that Krypton 87 and Xenon 137 have, respectively, just 51 and 83 neutrons in their structure. It is apparently just that last neutron which is lightly bound to the nucleus, and in the presence of quite slight excitation the nucleus lets it go. Similar considerations hold with regard to the new delayed neutron emitter, Nitrogen 17. Beta emission leads to Oxygen 17, which, in a state of excitation, might easily lose a neutron to become the tightly bound Oxygen 16. One might predict on this basis that Boron 13 might also carry delayed neutron activity, although, if so, it probably would have been revealed in the Berkeley bombardments unless its half-life were very short.

Neutrons in the Atmosphere

Cosmic-ray researchers have known for years that free neutrons exist in the atmosphere and that their concentration increases with altitude. An estimate (*14*) on the fast-neutron flux gives several hundred per square centimeter per day at an altitude of 10,000 feet. The fast neutrons are accompanied by neutrons which have been slowed down by collisions in the air, and the latter presumably disappear mostly by capture in nitrogen. It is generally thought that the neutrons are secondary particles, originating from the nuclear explosions which are evidenced by "stars" found in photographic emulsions. Proton tracks are frequently found in the "stars," and it would be peculiar if neutrons (which would make no emulsion tracks) were not emitted in the same events approximately as abundantly as the protons. This mechanism for the origin of the fast neutrons is borne out in a rough quantitative way by a comparison of the numbers of fast neutrons and of star protons, allowance being made for their difference in range in the atmosphere. Another argument for a secondary nature of the neutrons is that they are presumably radioactive, and they therefore would not live long enough to arrive at the earth from the outer regions of space; however, so far as this argument goes, some could perhaps come from the sun.

Fairly complete data on the distribution of fast and slow neutrons as a function of altitude have been obtained by Los Alamos workers by means of counters carried aloft in B-29 aircraft (*1*). The experiments covered the range 10,000–36,000 feet. The counting rates increased uniformly with altitude, doubling for approximately every 8 cm of mercury reduction in barometric pressure. This rate of variation is also that of the total cosmic-ray ionization, produced mainly by the soft component—a fact which also argues for the secondary nature of the origin of the neutrons. Now it is well known that the curve for the ionization arising from cosmic radiation reaches a peak at high altitudes; above the height corresponding to a barometric pressure of 7 cm of mercury the ionization drops again abruptly. If the neutrons are really secondary in origin, they should also show this peak. Curiously enough, the rather fragmentary data so far obtained in balloon flights to extreme altitudes (*17*) show, at most, a flattening off of the neutron counting rate at heights corresponding to barometric pressures of 5 and even 2 cm of mercury. If there is a maximum, it is therefore apparently much higher than is to be expected. One might think that this means that some or all of the neutrons found at that height come either from outer space or from some cosmic-ray component which generates them near the very top of the atmosphere. On the other hand, it is pointed out (*14*) that the position of the neutron maximum is determined primarily by the distance through which neutrons go in the course of being slowed down, and this distance would place the maximum at the lower altitude, even if the neutrons were all made at the most extreme heights. The conflict is therefore between experiment and diffusion theory, rather than between experiment and the postulated source. If there were an especially good slowing-down agent in the composition of the atmosphere at

great heights (e.g. water vapor), or if the neutrons were born with, on the average, only a few hundred kilovolts of primary energy, then the conflict could be resolved; however, neither possibility seems likely.

Other Consequences of the Wave Properties of Neutrons

We have already mentioned neutron crystal spectrometry and dismissed it as a subject which will be dealt with lightly here. While it is, nevertheless, the most important field in which the wave properties of neutrons are directly exploited in the laboratory, there are two other manifestations which are rather pretty and which deserve mention. One of these is a trick for obtaining a pure beam of ultra-slow neutrons (*3*). Suppose there is a large block of graphite, say a 4-foot cube, in which thermal neutrons are diffusing. The neutrons will have a Maxwellian distribution about a most probable velocity of 2,000–3,000 m/sec (which corresponds to thermal energies at room temperature), but there will be a few in the distribution with much higher velocities and a few with very low velocities. Now suppose the graphite block to be covered with sheet cadmium so that none of the neutrons become nuisances by emerging into the room, and further suppose that a 4×4 inch hole is cut in the cadmium near the center of the top face. Now let us stand a 4×4 inch piece of graphite on this hole, so that it makes a chimney about a foot high. The sides of the chimney may be covered with cadmium, but the top must be left uncovered. Now consider what happens to the neutrons which enter the base of the chimney. Those with thermal energies or higher can suffer Bragg reflections from the crystals in the graphite, as can be seen by putting numbers in the Bragg relation, $\lambda = 2d \sin \theta$. Here the wave length, λ, of thermal neutrons is around 2 A, and the lattice distance, d, is 3.3 A in the graphite crystals. Clearly, there will be a range of values of λ up to 6.6 A, for which there are Bragg angles, θ, appropriate to crystal scattering. Neutrons with these wave lengths will very probably be scattered sideways in the graphite chimney and will be swallowed by the surrounding cadmium. On the other hand, the crystal scattering is impossible for neutrons with wave lengths greater than 6.6 A, and these neutrons are consequently preferentially transmitted. Thus, the crystal effects enable the chimney to act as a filter whereby all but the very slowest of the neutrons in the large graphite block are removed from the mixture. The transmitted neutrons have energies corresponding to thermal energies at about 18° K and can be used for special experimental purposes. Because of intensity considerations, it is practically essential to use a nuclear reactor for the primary neutron source; our hypothetical cadmium-covered graphite block then becomes one of the "thermal columns" which are customarily built into the concrete shields of reactors.

Our second wave effect occurs at the other extreme of the energy scale. It concerns ultra-fast neutrons and the Fraunhofer diffraction of their waves by nuclei. The case under consideration is that of the diffraction of plane waves by an opaque disc or sphere. Physical optics says that there should be a bright maximum in the center of the "shadow" of the object, and that this maximum should be surrounded by rings of alternating maxima and minima of radially dimishing intensity. The results are conditional upon the wave length of the light being smaller than the radius of the opaque object. This condition is fulfilled very well in the case of the 90-Mev neutron beam from the Berkeley cyclotron, for the neutron wave length is considerably smaller than the dimensions of any but the smallest nuclei. In the experiments (*18*) spheres of aluminum, copper, and lead were placed in the fast neutron beam, and detectors were placed at positions making angles at the sphere of 3°–30° with the direction in which the beam was going. The detectors were graphite blocks, which are sensitive to fast neutrons by virtue of the 20 min Carbon 11 activity induced by the reaction $C^{12}(n,2n)C^{11}$. The central diffraction maxima were strongly present, and the theory was further corroborated, in that the smaller opaque objects (aluminum nuclei) gave a broader diffraction maximum than did the larger opaque objects (lead nuclei). It is true that the lesser maxima and minima were not convincingly observed, but it is, nevertheless, clear that some of the laws of physical optics were here being corroborated on a scale some 10^8 times smaller than that of the classical light experiments.

Radioactive Decay of the Neutron

The first accurate value of the mass of the neutron was obtained in 1935. The result showed that the neutron is appreciably heavier than the proton, and it was immediately suggested (*6*) that neutrons should be beta radioactive in common with other nuclei under like circumstances. Modern values of the neutron-proton mass difference indicate that the beta-particles should have an upper energy limit of 0.75 Mev, and beta-decay theory says that the associated half-life should be about ½ hr. This prediction has since remained on the books as a challenge to the experimentalists. A start on the problem was made at Berkeley (*2*), but the work was interrupted by the war. A new attack is now in progress at the Oak Ridge National Laboratory (*25*). A collimated beam

of neutrons (mostly slow) is taken from a hole in the shield of the nuclear reactor and is allowed to pass axially through a horizontal, cylindrical tank which is highly evacuated (Fig. 3). The beam enters and

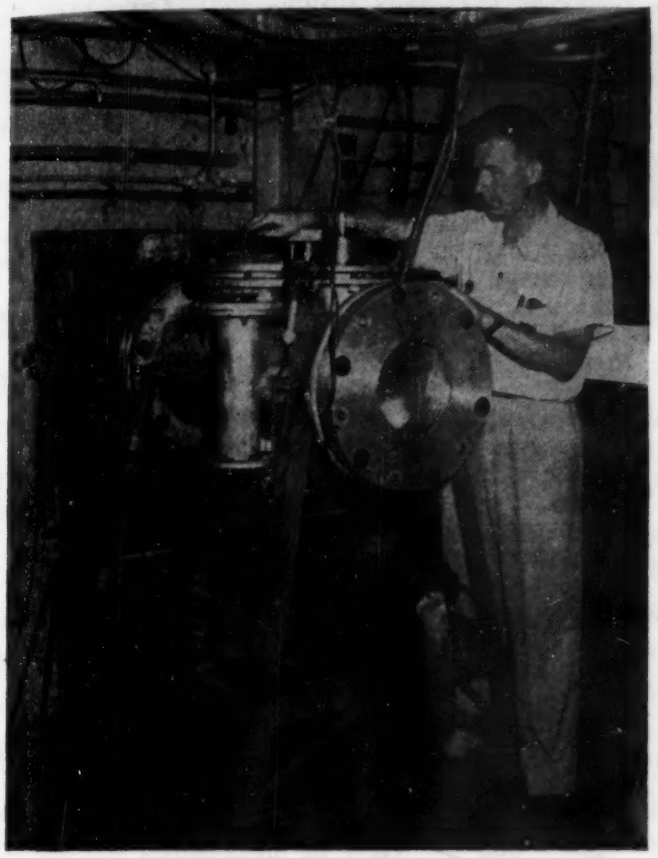


FIG. 3. Apparatus used for studying the radioactivity of the neutron. A beam of neutrons is taken from a hole in the concrete shield of the Oak Ridge reactor (background) and passes through the horizontal evacuated tank. Apparatus for counting the decay protons is inside the tank. The "bull's-eye" on the end of the tank is the thin aluminum window through which the beam emerges, to be caught finally in a heavy boron-laden, lead-shielded "beam-catcher" 10′ away.

leaves the tank through thin aluminum windows. In the vacuum, protons are presumably being formed by the decaying neutrons, and an electrostatic field is arranged so that any such protons would be accelerated in a direction perpendicular to the beam and focused upon a secondary electron multiplier which would count them. Counts are indeed observed, and this brings us to the difficult part of the experiment: How can one tell with certainty whether the counts are really coming from decaying neutrons and not from various secondary ionization processes which might be taking place because of the interaction of the gamma rays, fast and slow neutrons, and secondary electrons in the original beam with the tank walls or the residual gas in the vacuum? One rather convincing way would be to put a beta counter in the tank and look for coincidences between the beta-particles of the neutron decay and the collected protons. This is being tried, but at the moment of writing it has not given reproducible results. Another way is to work solely with the multiplier and to make subsidiary tests to see if anything imaginable besides neutron decay can be causing the counts. Thus, it is found that out of a total counting rate of about 400/min, about 100/min disappear if one does *either* of the following three things: (1) places a thin layer of boron in the beam ahead of the entrance into the vacuum; (2) places a thin foil over the entrance to the multiplier; (3) turns off the electrostatic field. Furthermore, if the boron is moved in and out of the beam while the foil is in front of the multiplier or while the electrostatic field is absent, then there is no change in the counting rate. Taken together, these observations show that the presence of the boron eliminates some positive ions of low energy which are otherwise formed in the collecting region and counted in the multiplier. These positive ions may be the decay protons; it remains to make sure. Now the predominant effect of the boron shutter is to eliminate the slow neutron component of the beam; it is too thin to affect the fast neutron component, but it admittedly may affect the secondary electron component, and it definitely will affect the the gamma-ray component by *introducing* a new source consisting of the gamma radiation emitted when it captures slow neutrons. The extent of the former of these possibilities was tested by substituting an aluminum shutter for the boron; the counting rates were unaffected by the presence or absence of the aluminum. The second possibility was tested with a radioactive pure gamma source placed at the position of the boron shutter when all neutrons were absent (reactor off). The gamma source affected the multiplier directly, but did not make positive ions, as evidenced by the insensitivity of the counting rate to the foil in front of the multiplier and to the presence of the electrostatic field. We are therefore led to the conclusion that *slow neutrons* produce the 100 counts/min of positive ions. This is what would be expected if the positive ions are decay protons, because the slow neutrons are far more dense in the beam than are the fast neutrons. However, we must still make sure that there are no processes other than neutron decay by which the slow neutrons could produce the positive ions. They are not sufficiently energetic to ionize directly, so the only mechanism would seem to be through the gamma rays (with their associated secondary electrons) excited when the neutrons are captured. To see if ionization could be taking place in the residual gas in the vacuum tank, the boron-difference counting rate was studied as the gas pressure was raised over a factor of 8; the 100 counts/min remained practically unchanged. Finally, the pure gamma source was brought up again, and it was demonstrated that for equivalent total counting rates in the multiplier, the

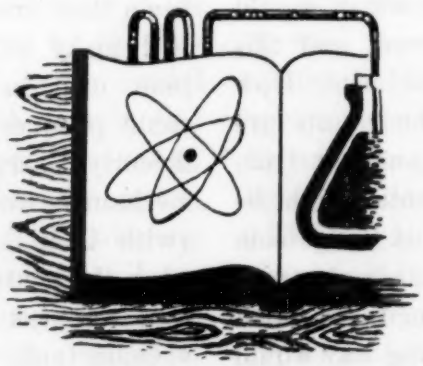
gamma source produced very few positive ions in the collecting volume. Thus, a chain of experimental eliminations enables one to say that the observations are easily explicable on the basis of decaying neutrons, but explicable only with great difficulty on the basis of other imaginable experimental effects.

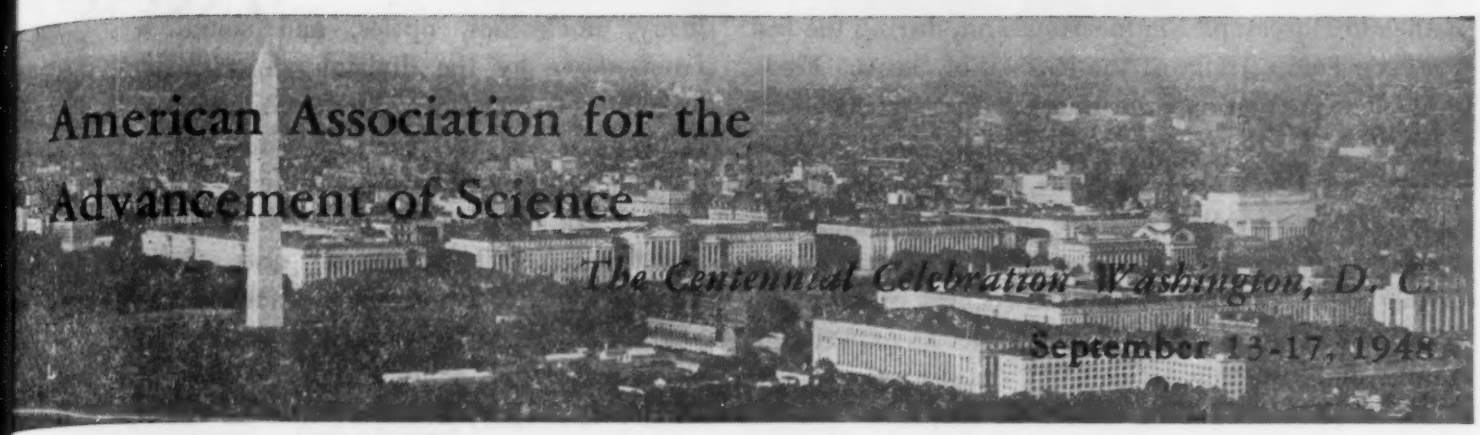
The neutron half-life can be estimated from this experiment, for the collecting and counting efficiency of the apparatus can be evaluated, and the number of neutrons in the portion of the beam under observation can be determined by foil activation measurements. The answer so far obtained is rough, but it indicates a half-life of about ½ hr, as predicted by theory.

Any one of the topics mentioned in the foregoing survey of this broad subject could obviously be greatly expanded. Also, there is much in neutron physics which we have failed to mention, as for example, the basic subject of the absolute standardization of neutron sources; a discussion of theoretical background; the interesting experiments on scattering from ortho- and para-hydrogen, and their significance in terms of nuclear forces; and the fancier aspects of slowing-down theory and experiment, such as the measurements of transport cross sections. It would also have been interesting to include a paragraph on the fascinating speculations as to the possible roles of neutrons in stellar evolution. In spite of these serious omissions, perhaps enough has been said to give the reader an impression of the range of the subject and its variety. Perhaps we have shown that Rutherford was right, particularly when he spoke of the "very novel properties" of the "atoms" which we now know as neutrons.

References

1. AGNEW, H. H., BRIGHT, W. C., and FROMAN, D. K. *Phys. Rev.*, 1947, **72**, 203.
2. ALVAREZ, L. W., and TOBIAS, C. A. Unpublished.
3. ANDERSON, H. L., FERMI, E., and MARSHALL, L. *Phys. Rev.*, 1946, **70**, 815.
4. BERKELEY CYCLOTRON GROUP. *Bull. Amer. phys. Soc.*, 1948, **23**, 20.
5. BURGY, M., HUGHES, D. J., and WALLACE, J. R. *Bull. Amer. phys. Soc.*, 1948, **23**, 9.
6. CHADWICK, J., and GOLDHABER, M. *Proc. roy. Soc.*, 1935, **A151**, 479.
7. COOK, L. J., MCMILLAN, E. M., PETERSON, J. M. and SEWELL, D. C. *Phys. Rev.*, 1947, **72**, 1264.
8. FERMI, E., MARSHALL, J., and MARSHALL, L. *Phys. Rev.*, 1947, **72**, 193; BRILL, T., and LICHTENBERGER, H. *Phys. Rev.*, 1947, **72**, 585.
9. FERMI, E., and MARSHALL, L. *Phys. Rev.*, 1947, **72**, 1139.
10. FIELDS, R., RUSSELL, B., SACHS, D., and WATTENBERG, A. *Phys. Rev.*, 1947, **71**, 508.
11. GOLDSMITH, H. H., IBSER, A. W., and FELD, B. T. *Rev. mod. Phys.*, 1947, **19**, 259 (Fig. 21).
12. HARRIS, S. P., LANGSDORF, A. S., and SEIDL, F. G. P. *Phys. Rev.*, 1947, **72**, 866; *Bull. Amer. phys. Soc.*, 1948, **23**, 19.
13. HAVENS, W. W., RABI, I. I., and RAINWATER, L. J. *Phys. Rev.*, 1947, **72**, 634.
14. HEISENBERG, W. *Cosmic radiation.* New York: Dover, 1946. Chaps. 13 and 14.
15. HELMHOLZ, A. C., MCMILLAN, E. M., and SEWELL, D. C. *Phys. Rev.*, 1947, **72**, 1003; SERBER, R. *Phys. Rev.*, 1947, **72**, 1008.
16. HUGHES, D. J., WALLACE, J. R., and HOLTZMAN, R. H. *Phys. Rev.*, 1948, **73**, 1277.
17. KORFF, S. A., and COBAS, A. *Phys. Rev.*, 1948, **73**, 1010.
18. MCMILLAN, E. M. Washington meeting of the American Physical Society, May 29, 1948.
19. MAYER, M. G. AEC Declassified Document No. 1818.
20. RAINWATER, J., and HAVENS, W. W. *Phys. Rev.*, 1946, **70**, 136.
21. RUTHERFORD, E. *Proc. roy. Soc.*, 1920, **A97**, 374.
22. SHERR, R. *Phys. Rev.*, 1945, **68**, 240.
23. SHULL, C. G., and WOLLAN, E. O. *Science*, 1948, **108**, 69.
24. SNELL, A. H., *et al.* *Phys. Rev.*, 1947, **72**, 545.
25. SNELL, A. H., and MILLER, L. C. *Bull. Amer. phys. Soc.*, 1948, **23**, 21.
26. SUGARMAN, N. AEC Declassified Document No. 1873.





The U. S. Naval Research Laboratory

On the east bank of the Potomac River, just within the southern corner of the District of Columbia and opposite the historic city of Alexandria, Virginia, stands one of the important research establishments of the Navy. Sprung from modest beginnings some 25 years ago, the U. S. Naval Research Laboratory today comprises extensive laboratories, shops, and administrative offices, and its staff includes some 3,000 scientific, technical, managerial, and clerical employees.

The mission of NRL, as originally defined, was "to increase the safety, reliability, and efficiency of the Fleet by the application of scientific and laboratory experimentation to naval problems." NRL has in its history been a field activity of several different Navy Department bureaus and offices, and its program has been modified by each. But, by and large, its staff has devoted its energies to basic research, except during war, when the needs for development, experimentation, and even testing are paramount. Continually growing demands on the part of the Service have necessitated progressive expansion of the Laboratory so that the plant is now well equipped to carry on almost any type of scientific investigation.

The numerous permanent and temporary buildings, all of harmonious external appearance and distributed around a landscaped mall, are specially designed to meet definite requirements. The laboratory buildings, which are in the majority, compare favorably with modern industrial laboratories and are so designed that space may be added to, or subtracted from, individual rooms by means of demountable bulkheads. Included are shop facilities for metal-, plastics-, and wood-working, each consolidated in a separate large building, and at the river end of the mall is located the administration building. Since the Laboratory is conveniently situated on tidewater, a wharf is also provided which accommodates small vessels with drafts up to 18′. A converted patrol craft is assigned permanently for test work in open waters.

Laboratory equipment is, in general, of the very finest and includes some pieces of apparatus and certain facilities unavailable elsewhere. In a number of instances, highly specialized units have been designed and built in the Laboratory itself whenever such units were unobtainable on the open market. Among those of particular interest are the 20-Mev betatron; an RCA electron microscope; and an altitude chamber which simulates changes in pressure, temperature, and humidity experienced by aviators.

That most of the expansion to present size and importance took place during the period 1940–45 provides some measure of the responsibility of NRL in the conduct of World War II. But, as an institution, the Laboratory owes its origin to the foresight and initiative largely of two men. As early as 1910, Thomas A. Edison recognized the need for a research organization dedicated to the interests of the Navy, and by 1915 certain of his public statements on this matter had come to the attention of Josephus Daniels, then Navy Secretary. In July of the latter year, Daniels wrote Mr. Edison, stating his intention to establish a department of invention and development and asking whether he, Edison, as a public service, would be willing to act as chairman of a board of consultants. Acceptance of this post by Mr. Edison led shortly thereafter to the establishment of the Naval Consulting Board, composed of representatives of the 11 largest technical societies in the United States and including a number of distinguished scientists and administrators.

Armed with the recommendations of the Consulting Board, Daniels took the matter before Congress, and in 1916 the House passed an appropriation of $1,000,000 for the construction of the Laboratory and $500,000 for the initial year of operation. Because of the unusual situation arising from World War I, however, formal opening of the new facility was delayed until July 2, 1923, and accordingly the 25th anniversary of NRL has just been celebrated this year.

During its first quarter-century, NRL has operated variously under the Secretary of the Navy, as a part

of the old Bureau of Engineering, and, during the last war, as a field activity of the Bureau of Ships. Early in 1945, in a merger toward an all-Navy scientific organization, NRL was transferred to the Office of Research and Inventions, now the Office of Naval Research. But regardless of these changes in cognizance, the Laboratory has tackled technical problems for all of the naval bureaus. Upon the request of a bureau or office, NRL undertakes either to act as expert consultant or to assume active work on any scientific or technical problem falling within its scope.

Since its inception, the internal organization of NRL has followed the pattern conceived originally by the Consulting Board—that of a laboratory operated by civilian scientists under Navy management and devoted to the scientific interests of the Navy. The higher administrative and liaison posts are filled by naval officers chosen for their engineering or scientific background. Naval personnel serve tours of duty of two to four years, so that outgoing officers carry back to the Fleet a definite experience with the scientific method and its latest naval developments. Similarly, the replacement officers coming directly from the Fleet bring to the Laboratory the immediate problems and operating experience of the Service afloat, under water, and in the air.

The civilian scientific organization, on the other hand, is permanent and is afforded full authority and responsibility for the conduct of its work. Having been considered by the Program Board and accepted, a problem is assigned to the appropriate division of the scientific staff. Thereafter the administration avoids interference with the program and in no case attempts to direct the research. Ten research Divisions, each under a competent scientist as superintendent, have been established—three in radio and one each in chemistry, electricity, mechanics, metallurgy, nucleonics, optics, and sound. Coordinated from above by the division superintendents and a director of research, the Divisions are subdivided below into sections, each of which deals with some definite type of scientific problem.

That this combination of officer and civilian control has functioned harmoniously and effectively is evidenced by NRL's remarkable achievements over the years. For security reasons, details of many of the most important contributions cannot be discussed. Suffice it to say, however, that in the whole broad fields of radio communication, detection and range-finding, and guided missiles, and particularly in the development of radar, the Laboratory has been a pioneer. Many of the important developments in underwater sound gear and in naval applications of physical optics may also be claimed for NRL, as well as highly significant accomplishments in antifouling paints, rain-repellent films, hydraulic fluids, nonpetroleum lubricating oils and greases, fire-fighting foams, and many other products of special application.

Little known is the fact that NRL initiated one of the first methods for separating U-235 from U-238 for the production of atomic energy. On display in the exhibit room (open to visitors) is a model of the original liquid thermal diffusion plant in which the first successful separation by this process was accomplished (Abelson, 1940–41). Also to be seen, together with numerous other examples of the Laboratory's success, is an exhibit of "Window," used during the recent war to clutter enemy radar.

But, as is the case in most active laboratories, the achievements of NRL seem dwarfed by the new problems created by the new knowledge. The end of conflict heralded a return to many fundamental investigations which may be expected ultimately to contribute to the general peacetime welfare of the Nation.

The Naval Research Laboratory is another among the many institutions in and around Washington which will serve as hosts during the forthcoming Centennial Celebration. It is hoped that these brief sketches of host institutions which have appeared in *Science* during past weeks and which will also be published in the two remaining premeeting issues will be useful to those attending the meetings who wish to avail themselves of the opportunity to visit the many laboratories, colleges, and universities at which research is being conducted around the Nation's capital.

NEWS and Notes

O. Hobart Mowrer, director of the Psycho-Educational Clinic at Harvard University, has accepted an appointment as research professor of psychology in the University of Illinois Graduate School. One of Prof. Mowrer's major assignments at the University will be a broad study of research and instruction in human behavior in all its manifestations.

Charles H. Behre, Jr., professor of economic geology, Columbia University, has been granted a leave of absence for the year 1948–49 to continue the study, begun two years ago, of the genesis, distribution, and geologic control of the mineral deposits of Mexico. **T. S. Lovering,** of the U. S. Geological Survey, and **Donald M. Davidson,** consulting geologist with the E. J. Longyear Company, have accepted invitations to lecture in the Department of Geology during October and November, respectively. Their lectures will give special emphasis to ore genesis and its influence on minerals search.

Howard H. Vogel, Jr., has resigned from the Department of Zoology, Wabash College, and has accepted the chairmanship of Biological Sciences in the College of the University of Chicago. He may be reached through the University's Faculty Exchange.

William von Fischer, a member of the Case Institute of Technology faculty since 1937, has been appointed head of the Department of Chemistry and Chemical Engineering. He has been acting head of the Department since March of this year.

Wendell H. Griffith, professor of biochemistry, St. Louis University Medical School, has been appointed professor of biochemistry and nutrition and chairman of the Department at the University of Texas Medical Branch, Galveston. During World War II Dr. Griffith served as a Colonel in the Sanitary Corps and was responsible for nutrition surveys among American troops.

Frank Dana Carvin, head of the Mechanical Engineering Department and chairman of the Graduate Division at Newark (New Jersey) College of Engineering, has been named head of the Department of Mechanical Engineering at Illinois Institute of Technology, effective September 1.

Ladislaus Marton, chief of the Electron Physics Section, National Bureau of Standards, is spending the summer in Europe to survey work in the field of electron microscopy. In addition to attending numerous conferences and symposia, Dr. Marton will assist in initiating and organizing electron-optics research in Belgium and will also be on the faculty of the summer school of the Cavendish Laboratory at Cambridge University.

Charles C. Scott, formerly head of the Department of General Pharmacology, Eli Lilly and Company, recently became associated with the Inlow Clinic, Shelbyville, Indiana, where he is practicing internal medicine.

Lt. Col. Hubert G. Schenck, chief of the Natural Resources Section, General Headquarters, Supreme Commander for the Allied Powers, and **Sherman K. Neuschel,** chief of the Pacific Geological Surveys, Engineer Office, General Headquarters, Far East Command, will represent Gen. Douglas MacArthur at the 18th International Geological Congress in London.

Charles E. Packard, associate professor of biology at Alfred University, has resigned, effective September 1, to accept a similar position at Randolph-Macon College, Ashland, Virginia.

James V. Quagliano is joining the staff of the University of Notre Dame as assistant professor of chemistry. He has held a similar position at the University of Maryland.

C. S. Gwynne, associate professor of geology at Iowa State College, is serving as visiting professor of engineering geology at the University of Puerto Rico Mayaguez, until December 15.

John S. Karling has resigned from Columbia University to become professor of botany and chairman of the Department of Biological Sciences at Purdue University, Lafayette, Indiana. He will assume his new duties there in the fall.

Benjamin A. Fisher, professor of electrical engineering at the University of Denver, has been appointed associate professor at Illinois Institute of Technology, effective September 1.

Grants and Awards

The Medal for the Advancement of Research, bestowed annually by the American Society for Metals, will be presented this year to Willard H. Dow, president of the Dow Chemical Company, Midland, Michigan, at the Society's annual banquet, to be held in Philadelphia, October 28, during the National Metal Congress and Exposition. This medal, first awarded in 1943, has gone to executives of industrial organizations principally devoted to the production or fabrication of metals.

A special study on the action of antibiotics in promoting healing in surgical wounds will be made by Edgar J. Poth, professor of surgery and director of the Surgical Research Laboratory, University of Texas Medical Branch, under a grant of $3,000 recently received from the Upjohn Company. Dr. Poth will discuss some of the results of his studies thus far at the Fourth Pan-American Surgical Congress to be held in Honolulu August 30–September 10.

W. R. Hinshaw, professor of veterinary science at the University of California's College of Agriculture, has recently received two awards for his contributions to the field of poultry diseases and especially for his researches on avian salmonellosis and diseases of turkeys. The first of these is the 10th annual Borden Award, consisting of $1,000 and a gold medal and given by the Borden Foundation and the Poultry Science Association; the second, the annual research award given by the National Turkey Federation, which consists of $500 and a bronze plaque.

U. S. and Canadian medical schools are invited by the John and Mary R. Markle Foundation to make nominations for the second group of Scholars in Medical Science on or before December 1 of this year. Each school, through the dean, may nominate one candidate. Suggestions or applications from individuals will not be considered. This program is designed to aid young men and women of ability who are planning careers in academic medicine. According to the Foundation, candidates should have completed the usual fellowship training in some area of science related to medicine and should hold, or expect to hold, in the academic year 1949–50 a full-time faculty appointment on the staff of a medical school. Grants are for $25,000, payable in amounts of $5,000 over a 5-year period to the schools at which the Scholars carry on their research.

A booklet describing the program is available on request from the Foundation's office at 14 Wall Street, New York City 5.

Colleges and Universities

A series of lectures on modern chemistry is again being sponsored by Northwestern University during the coming fall quarter. The subject this year will be on recent trends in biochemistry, the lectures being given as usual on Tuesday evenings in the University's Lincoln Hall, located on East Chicago Avenue, Chicago, Illinois. The lectures constitute a non-credit course and are open only to those who have paid the usual fee for the course. That these lectures help to fulfill a definite need is borne out by the continued and increasing support given them by scientists in the Chicago area. Inquiries concerning the series may be addressed either to the Office of the University College, Abbott Hall, Northwestern University, Chicago, Illinois, or to Byron Riegel, Department of Chemistry, Northwestern University, Evanston, Illinois. Lecture dates, subjects, and speakers are as follows:

September 28, "Lipids of the Nervous System," H. E. Carter, University of Illinois; October 5, "Steroid Metabolism," Konrad Dobriner, Sloan-Kettering Institute for Cancer Research; October 12, "Enzymes," David E. Green, University of Wisconsin; October 19, "Carbon Dioxide Metabolism," C. H. Werkman, Iowa State College; October 26, "Recent Advances in Carbohydrate Metabolism," Carl F. Cori, Washington University School of Medicine; November 2, "Protein Molecules: Size, Shape, and Electric Charge Distribution," John T. Edsall, Harvard Medical School; November 9, "The Dietary Significance of the Amino Acids," William C. Rose, University of Illinois; November 16, "The Metabolism of Organic Acids in Plant Leaves," H. B. Vickery, Connecticut Agricultural Experiment Station; November 23, "Synthetic Penicillin," Vincent du Vigneaud, Cornell University Medical College; November 30, "The Physiology of Folic Acid and Related Vitamins," C. A. Elvehjem, University of Wisconsin; and December 7, "Recent Investigations on the Biosynthesis of Heme," David Rittenberg, College of Physicians and Surgeons, Columbia University.

The University of Hawaii has appointed several additional members to the staff of the Department of Zoology and Entomology in order to expand the program of instruction and research in marine zoology. M. W. de Laubenfels, formerly visiting professor in the Department and outstanding authority on the Porifera, has become professor of zoology and entomology. Albert L. Tester, formerly senior biologist in charge of the Herring Investigation for the Fisheries Research Board of Canada at Nanaimo, British Columbia, has become professor of zoology and entomology in charge of instruction and research in fishery biology and biometrics. Bradley T. Scheer, formerly assistant professor of biochemistry, University of Southern California, and presently engaged in research at the Kristineberg Marine Station and at the Wenner-Grens Institute in Sweden, has become associate professor of zoology and entomology in charge of instruction and research in general and comparative physiology. William A. Gosline, formerly assistant curator of Fishes, Museum of Zoology, University of Michigan, has become associate professor of zoology and entomology in charge of instruction and research in chordate anatomy and ichthyology. Each of the above men will devote a substantial portion of his time to the research program in marine zoology and fisheries biology at the University's new Hawaii Marine Laboratory at Coconut Island, in cooperation with the Territorial Division of Fish and Game and the Farrington Fisheries Program recently established in Hawaii for the Central and South Pacific by the U. S. Fish and Wildlife Service. Inger Achton, scientific illustrator who has recently been at the American Museum of Natural History and is presently at the California Institute of Technology, will join the staff in January in this capacity.

Summer Programs

Thirty-two staff members representing 15 universities and medical institutions located in the East, Southeast, Southwest, and Far West will next week begin the final week of a four-week course at Oak Ridge in the techniques of using radioisotopes in medical and biological research. The personnel attending the radioisotope school will train the recipients of the large number of fellowships to be granted at their respective institutions to holders of M. D.'s, Ph. D.'s in the biological sciences, B. S.'s, and B. A.'s who will receive training in health physics and who, it is hoped, will become leaders in the future development of medical and biological education in the atomic energy field. Over half of those attending the current course previously participated in a group of seminars at Brookhaven National Laboratory in connection with the fellowship program.

The course now being given is the second of three offered this summer by the Oak Ridge Institute of Nuclear Studies under the direction of Ralph T. Overman, acting head of the Institute's Special Training Division. Dr. Overman is being assisted by H. M. Clark, associate professor of chemistry at Rensselaer Polytechnic Institute; Raymond D. Finkle, of Argonne National Laboratory; C. L. Comar, research chemist at the University of Florida; and Henry Lanz, of the Radiation Laboratory, University of California, Berkeley.

The Oak Ridge Institute is conducting its program of research and training in the nuclear sciences through a contract with the AEC.

Meetings and Elections

The International Northwestern Conference on Diseases of Nature Communicable to Man will hold its third annual meeting August 23–25 in Kamloops, British Columbia, with the Dominion Laboratory of Hygiene and the Dominion Entomological Laboratory serving as joint hosts.

The 9th Annual Research Conference of the Institutum Divi Thomae and its affiliated units will be held in Cincinnati, September 7–10, with Elton S. Cook, dean of research, as general chairman. More than 60 papers summarizing research completed during the past year will be presented in the fields of cancer, enzymes, growth, metabolism, microbiology, biophysics, and physical chemistry.

The Chemists' Club of New York, which is celebrating its 50th anniversary this year, is laying plans for an appropriate celebration. M. T. Bogert has been appointed honorary chairman of the committee in charge, which consists of H. B. Lowe (chairman), D. D. Berolzheimer, W. P. Cohoe, and H. B. McClure. In the years since its founding the Club has grown from a handful of chemists to the present membership of about 2,500. Honorary U. S. members of the Club are James B. Conant, Lamont du Pont, Maj. Gen. Fries, Irving Langmuir, Charles L. Parsons, Milton C. Whitaker, Willis R. Whitney, and Col. Bogert, while Sir Robert Robinson, Lord Leverhulme, and Dr. Kruyt, president of the International Union of Chemistry, comprise the foreign honorary membership.

A Symposium on Luminescence is being arranged by the Electronics Division of the Electrochemical Society in connection with the next meeting of the Society in Philadelphia, May 5–7, 1949. Although symposia of this kind have been held at previous annual meetings, the participants were for the most part members of the Society. In 1949, however, the Society hopes to make a greater contribution to the field by inviting papers from nonmembers engaged in work on luminescence. As in the past, an opportunity will be provided for an informal round-table discussion of all papers presented. An attempt will be made to gather together all original and phenomenological material pertaining to luminescence, both fundamental science and technical applications, for the purpose of providing a harmonious survey of the year's progress in the field at one forum once a year and thus reduce the number of outlets for luminescence subjects. Papers presented will be published in the monthly journal of the Society and later in the *Transactions,* together with all questions and discussions arising at the meetings. Those interested in presenting a paper at the next symposium should submit its title and an abstract by December 15 to R. M. Burns, Secretary, The Electrochemical Society, 235 West 102nd Street, New York City 25.

The 58th annual meeting of the Nebraska Academy of Sciences, held at the University of Nebraska, Lincoln, April 30–May 1, was well attended by Academy members and other interested persons from all colleges and universities in the state. High school teachers and students were also present in gratifying numbers, according to the corresponding secretary.

Officers for the fiscal year which started on May 1 are: president, Victor E. Levine, Creighton University; vice-president, F. L. Duley, University of Nebraska; secretary, C. B. Schultz, University of Nebraska; corresponding secretary, H. L. Weaver, University of Nebraska; treasurer, C. E. Rosenquist, University of Nebraska; and councilors, D. M. Pace, J. S. Latta, and W. F. Weiland, all of the University of Nebraska.

Iota Sigma Pi, women's national honorary chemical fraternity, elected the following officers at its triennial convention at State College, Pennsylvania, in June: president, Essie White Cohn, professor of chemistry, University of Denver; vice-president, Gladys A. Emerson, Merck Institute for Therapeutic Research, Rahway, New Jersey; secretary, Anna L. Hoffman, Cincinnati College of Pharmacy; treasurer, Nellie M. Naylor, Iowa State College, Ames; editor, Margaret G. Morehouse, University of Southern California, Los Angeles; and permanent historian, Agnes Fay Morgan, University of California, Berkeley.

At the annual meeting of the American Association of the History of Medicine, held at the College of Physicians of Philadelphia on May 26–27, Henry R. Viets, lecturer on neurology at the Harvard Medical School, was elected president and Benjamin Spector, professor of anatomy at Tufts Medical School, secretary for two years.

The next meeting will be held at Transylvania University in Lexington, Kentucky, on May 23–24, 1949.

More than 100 teachers, research workers, and senior students in biology from all the universities and institutions of Peiping met on the new campus of the College of Agriculture of National Tsinghua University, adjacent to the Summer Palace, from July 17 to 25 for a Summer Palace Conference on Experimental Biology. Samuel H. Zia, professor of bacteriology, has sent us a very interesting report of the meeting. Moving spirit of the Conference was Dean P. S. Tang, assisted by his colleagues in the College of Agriculture, "who moved heaven and earth to make the visiting scholars enjoy for a brief period the joys of a true vacation few have been able to afford during the past 10 years." Preliminary meetings consisted of lectures on the place of biology in ancient Chinese history and on the teaching methods of biology in colleges and high schools. In view of the many suggestions which were made on the latter subject, a special committee was appointed for further exploration of the field. The regular program of the Conference included symposia and lectures on recent advances in the study of genetics, nutrition, hormones, viruses and rickettsia, biophysics, and aviation physiology. At round-table meetings, attended chiefly by senior members, cytology, growth and development, immunology, and temperature effects on organisms were thoroughly and enthusiastically discussed. The Peiping Branch of the Chinese Society of Phytopathology participated in the Conference on two afternoons.

Dr. Zia points out that the greatest single result of the Conference was the

contacts made by all the members with each other. Most of them had never met before, although many have been working in the same or related fields.

Because of the outstanding success of this meeting it was unanimously voted to hold another such meeting next summer, at which time it is hoped that biologists from other parts of China and abroad may participate.

The American Geophysical Union has announced that Walter H. Bucher, of Columbia University, has been elected president of the Union to fill the unexpired term of the late Oscar E. Meinzer. This term will expire on June 30, 1950.

Deaths

Peter A. Bungart, 72, who for nearly 25 years was associated with the Department of Geology and Paleontology of the Cleveland Museum of Natural History, died July 30 in Lorain, Ohio. He was a distinguished collector and preparator of fossil fish, and, due largely to his efforts, the Museum now possesses the finest collection of fossil fish in the world.

Percy Hodge, 77, professor emeritus of physics at Stevens Institute of Technology, died August 4 in Memorial Hospital, Orange, New Jersey. Dr. Hodge was head of the Physics Department at Stevens from 1911 until his retirement in 1938.

Y. SubbaRow, 52, director of research for the Lederle Laboratories Division, American Cyanamid Company, died August 10 in Pearl River, New York. Dr. SubbaRow, India-born biochemist, was on the staff of the Harvard Medical School until 1940, when he became associated with the Lederle Laboratories.

The foundation stone of the Electrochemical Research Institute at Karaikudi (South India) was laid on July 25 by Prime Minister Jewaharlal Nehru. This Institute, which will be the first of its kind in India and seventh in a chain of national laboratories to aid in the industrial and scientific development of India, will initially have two main divisions dealing with electrolysis and electrothermy, together with auxiliary laboratories and workshops which will include an analytical section and a chemical engineering section. Although construction of the buildings, which will begin in a month or so, will not be completed for two or three years, it is expected that the laboratory will be functioning within a year.

Karaikudi will also be the site of an engineering college, to be opened in 1949, a research institute in higher mathematics to be called the Ramanujam Institute of Mathematics, and a technological and polytechnic institute.

Establishment of the National Heart Institute within the National Institutes of Health of the U. S. Public Health Service was announced on August 6 by Oscar R. Ewing, Federal Security Administrator. At the same time Leonard A. Scheele, Surgeon General of USPHS, announced that C. J. Van Slyke, who has been chief of the Division of Research Grants and Fellowships of the National Institutes of Health, had been named director of the Heart Institute, under the general supervision of R. E. Dyer, Assistant Surgeon General and director of the Institutes. In his position as chief of the Division of Research Grants and Fellowships Dr. Van Slyke will be succeeded by David E. Price, former chief of the Research Grants Branch, National Cancer Institute.

The Act of Congress creating the National Heart Institute was approved by President Truman on June 15 of this year. The program of the Institute will include research, financial aid to institutions for research and training of professional personnel, provision of fellowships to individual scientists, and grants-in-aid and technical assistance to the states for the development of heart disease control services. A National Advisory Council, appointment of which is provided under the Act, will be composed of outstanding scientists and clinicians working in the field of cardiovascular diseases and representatives of the public. This Council will advise the Surgeon General on all phases of the program developed both in the National Heart Institute and in other units of the Service.

The new Institute will have its headquarters at the National Institute of Health, Bethesda, Maryland.

A synthetic mica with the desirable characteristics of natural mica, used extensively for electronic equipment, has been produced for the first time under a coordinated research program sponsored by the Office of Naval Research, the Army Signal Corps, and the Navy's Bureau of Ships. Production of mica on a commercial scale will make the United States independent of foreign sources for this strategic material. The synthetic form, known as fluorine-phlogopite mica, now being produced on a pilot-plant scale, is expected to replace the muscovite and phlogopite forms of natural mica since it also gives perfect cleavage into thin sheets, has good electrical and mechanical properties, and is chemically stable.

Government-sponsored research on mica synthesis was initiated under a Signal Corps contract at the Colorado School of Mines on June 15, 1946, and on September 1, 1947, under a ONR contract, pilot-plant work was begun at the Interior Department's Bureau of Mines Electrotechnical Laboratory, located at Norris, Tennessee. ONR is developing a procedure for prompt and wide dissemination of the results of the work at the latter laboratory to the electrical, electronics, and other industries which might make use of synthetic mica, and interested organizations may obtain further details from that Office.

Make Plans for—

Regional Conference on Applied Statistics, September 7–9, Statistical Laboratory, Alabama Polytechnic Institute, Auburn.

American Mathematical Society, summer meeting, September 7–10, University of Wisconsin, Madison.

American Psychological Association, September 7–11, Hotel Statler, Boston, Massachusetts.

Third Symposium on Combustion and Flame and Explosion Phenomena, September 7–11, University of Wisconsin, Madison, Madison.

Biological Photographic Association, convention, September 8–10, Houston Hall, University of Pennsylvania, Philadelphia.

American Society for Horticultural Science and **American Society of Plant Physiologists,** annual meetings, September 8–10, Cincinnati, Ohio.

Comments and Communications

Depth of Field in Microscope Objectives

It would be unfortunate if microscopists encountering the need for increased depth of field in their work were to gain the impression that the procedure described by Roy J. Pence (*Science*, June 11, pp. 631–632) provided a method for circumventing one of the fundamental laws of optics.

"The necessity for *higher magnifications, with some corresponding degree of depth of focus without appreciable loss of definition and resolution*" simply cannot be met. It is not merely that ". . . when extreme depth of focus is attained, a certain amount of resolving power is necessarily sacrificed"; rather, the depth of field is strictly inversely proportional to the resolving power. The depth of field decreases as the aperture increases; the resolving power increases with the aperture.

It is disconcerting that submitting a paper for criticism to a faculty member in charge of Geometric Optics does not protect a biologist from falling into such an elementary error.

W. MARQUETTE

Pleasantville, New York

Surface Electrodes for Recording Bioelectric Potentials

Several types of electrode have been tested in this laboratory for a number of desirable characteristics in recording bioelectric phenomena from the skin surface of the intact, normal human subject. Desirable characteristics of the ideal electrode are: (1) maintenance of low-resistance contact for long periods of time; (2) absence of artifacts from bodily movement, vibration, or deformation of the skin; (3) comfort in wearing for long periods; (4) ease of application and removal; and (5) durability and low cost.

Metal electrodes, such as flattened drops of solder or silver cups, plates of "hats," all require a liquid adhesive such as collodion to make and keep a firm contact with the skin. The collodion takes time to apply and to dry, and usually the contact with the skin must be obtained with a paste or jelly placed under the electrode. Satisfactory contact with the skin is maintained by such electrodes, but their nuisance value to both experimenter and subject is high. If collodion or some similar adhesive is not used and surgeon's tape or Scotch tape is substituted to hold the electrode in place, the resistance level will change with movements of the skin from underlying muscles, particularly if the electrode is placed on a skin area in which wrinkling occurs. The effect of skin movement is to raise the rigid metal electrode from the surface of the skin, thus suddenly changing the surface area in contact with the electrode. This sudden change in area results in an increased resistance and will block the usual push-pull preamplifier and introduce artifacts into the record.

Most of the requirements listed above have been met in electrodes developed in this laboratory in connection with continuous recording of muscle action potentials over long periods of time. These electrodes are simple in construction, lightweight, easily attached and removed, comfortable to the subject, and maintain a constant uniform contact with the skin for long periods of time regardless of subcutaneous muscle movement.

The contact part of the electrode is made from sponge rubber $\frac{1}{2}''$ in diameter and $\frac{3}{16}''$ thick. The rubber discs are punched out of a flat sponge-rubber mat $\frac{3}{8}''$ thick and sealed on both sides. Each punched-out disc is then cut in two pieces, producing two electrode discs, each with a rough side and a sealed side. The stripped end of a cotton-covered, standard, flexible wire is pulled by a large needle laterally through the side of the disc, back out near the point of entry, and clipped flush with the side. This process will firmly connect wire and disc.

In use, the sealed side of the electrode is pressed to a piece of surgeon's tape or Scotch tape, and the rough side is then applied to the subject's skin on the area desired. The sponge is thoroughly moistened with saline to produce a liquid contact. These electrodes may also be mounted in a head-band or in special holders for recording the corneoretinal potential.

Some 40 subjects have been tested for change in resistance for periods up to 5 hrs. If the electrode contains enough fluid to wet the skin completely, the resistance between two such electrodes, placed $2\frac{1}{4}''$ apart on the forehead just above the eyebrows, usually decreases slightly with time. Initial resistance varied from 4,000 to 41,000 ohms, and final resistance, from 2,000 to 38,000 ohms. Thirty-two subjects showed a decrease, four subjects no change, and four an increase in final resistance level. The electrodes do not dry out rapidly, possibly because the normal perspiration of the skin, soaked up by the sponge, serves to maintain the fluid connection. Blocking of amplifiers due to surface change of electrodes has disappeared completely from our records since adopting the sponge-fluid electrode.

Some observations have been made on the possible use of these electrodes in electroencephalography. Satisfactory recordings of alpha have been obtained, using a head-band and placing the electrodes near the occipital region on top of the hair. The hair was parted to expose the scalp, but no effort was made to remove all hair under the electrode. Further exploration might possibly yield a more convenient way of attaching these electrodes for EEG purposes.

JOHN L. KENNEDY and ROLAND C. TRAVIS

Institute for Applied Experimental Psychology, Tufts College, Medford, Massachusetts

This may be considered the first step in the ... activity of some of the samples from the drill core are

TECHNICAL PAPERS

Some Mechanisms for the Fixation of Uranium in Certain Sediments

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During a spectrographic analysis of a drill core of bauxite (*1*) several very weak lines were measured which indicated that uranium was present in the core. Because the most sensitive uranium line (4,241.67) was obscured by a heavy zirconium line (4,241.687), two preliminary samples were tested in a beta counter. When compared with a standard containing 0.0004 gm of U_3O_8, one of the preliminary samples, consisting essentially of the mineral gibbsite, showed an equivalent amount of 0.0002 gm of U_3O_8 or 13.1×10^{-12} gm/gm of radium equivalent. The other sample contained 94% kaolinite and showed 9.6×10^{-12} gm/gm of Ra equivalent. These results indicate that the samples contained an amount of uranium that approached the threshold sensitivity of the spectrograph for this element.

The following remarks on the chemistry of uranium taken from Latimer (*2*) have geochemical significance: The oxides of UO_2 and UO_3, as well as the intermediate oxide U_3O_8 and probably $UO_2 \cdot 2UO_3$ or $U(UO_4)_2$, are stable. Complex ions of the +3 and +4 states exist in solutions. Hydrates of the trioxide, $UO_2 \cdot H_2O$ and $UO_3 \cdot 2H_2O$, are quite soluble in acids, forming the uranyl ion, UO_2^{++}. This UO_2^{++} ion is remarkably stable and has the properties of a large, simple, doubly charged metallic ion. It forms compounds that are slightly soluble, such as $Na_4UO_2(CO_3)_3$, $UO_2(IO_3)_2$, etc.

It is here suggested that the wide distribution of uranium throughout the sedimentary crust of the earth is due principally to its tendency to form large UO_2^{++} ions. The resulting large ionic radius is comparable with the radii of potassium, rubidium, cesium, and other large ions of low ionic potential[1] that concentrate only in the evaporates[2] if they are not first adsorbed by base exchange on the clays and other layer-lattice minerals.

If the above statements are correct, much of the uranium in shales may be in the form of adsorbed ions and not of discrete minerals. Whether or not this deduction is true is not known. Some support for this suggestion, however, may be implied from the work of Rothe (*3*). Tests of source rocks demonstrated that kaolin deposits showed very slight to no radioactivity. Rothe reported that clays found in a quarry of rhyolite had an exceptional activity. He also noticed a concentrati of radioactivity associated with "wad" deposits.

It is interesting to note that kaolinite, which h almost no base exchange capacity, also showed negligib radioactivity. Other clays, however, such as the mo morillonite, which develop from volcanic ash and ba flows, have a large base exchange capacity. While Rot did not specifically state the type of clay associated wi the Permian rhyolite that was so highly radioactive, it almost certain that it was a clay with high base excha capacity. This leads to the obvious conclusion: If t source rocks containing uranium are weathered to cla with a high base exchange capacity, these clays shou show high radioactivity.

A world-wide association of certain types of carbo aceous[3] material with vanadium and uranium materi has been observed. This close association must be d to some unique feature of the chemistry of carbon, t principal characteristic of which is its four tetrahed electron pair bonds and the remarkable stability of th bonds with hydrogen, oxygen, nitrogen, sulfur, the ha gens, and especially with other carbon atoms. All for of so-called amorphous carbon, from lampblack and co to charcoal, are graphitic in character. They are co posed of portions of the graphite structure without, ho ever, the regular 3-dimensional periodicity characteris of crystalline graphite. Because of its structure, w its extensive internal surfaces and unsatisfied valenci charcoal (and similar forms of carbon) possesses t property of adsorbing ions to a remarkable extent. T layer structure of graphitic material behaves in much t same manner as do certain of the layer-lattice clay m erals. Oxygen atoms may attach themselves to t graphite sheets and cause them to swell, forming the called graphitic oxides. Water may then be adsor until two layers of water molecules are between succes layers of graphite.

It is important to note that the unique UO_2^{++} ion c sists of two oxygen atoms located at opposite sides of t uranium atom. It is quite possible that this UO_2^{++} ion adsorbed between the graphite layers of carbonace material, forming a strong structure due to the sta UO_2^{++} ion holding the two layers together. In this m ner uranium may be concentrated to a remarkable deg in carbonaceous materials.

A possible method of concentration of uranium in se mentary deposits containing carbon may then be follows:

Uranium ions are released, on weathering, from granitic, rhyolitic, etc. rocks in which they occur in r tively large amount and are then adsorbed by base change phenomena on layer-lattice minerals such as c

[1] Ionic potential $= \frac{Z}{r}$, where Z = valence of the ion and r = the ionic radius.

[2] Evaporates are saline deposits such as salts found in desert basins, etc.

[3] The word "carbonaceous" is used to denote that type material containing carbon of an organic source.

ain clays. This may be considered the first step in the rocess of concentration of the uranium.

Because of an increase in the thermal environment of he clays, aging of the material, or the introduction of hemically more active ions into the system, the uranium s displaced and again put into solution. Carbonaceous naterial, in the path of the displaced ions, would act as "filter" and again concentrate, and this time fix, the ranium ions.

For the concentration of uranium according to the bove suggestions it is probably important that an oxi- izing environment prevail. Alkaline solutions cause the raphite layers to expand to such an extent that they ay be converted into a colloidal suspension, leading to final breakdown of the graphite structure. Colloids ontaining uranium would then be adsorbed again on lays and similar minerals.[4]

The above discussion does not, however, account for the ranium in the bauxite core. The clay mineral in the ore is kaolinite, a clay with very little base exchange apacity. The drill core contained siderite distributed hroughout its entire length. The carbonate solutions of igh pH should disperse or leach the uranium from the ore. When tested in the beta counter, the siderite-rich naterial showed almost no radioactivity.

The drill core contained large amounts of titanium and irconium. These elements form ions similar to the ranyl ion:

$$UO_2(OH)_2 \rightarrow TiO^{++} + 2OH$$
$$ZrO(OH)_2 \rightarrow ZrO^{++} + 2OH$$
$$UO_2(OH)_2 \rightarrow UO_2^{++} + 2OH$$

ertain portions of the drill core that contained no itanium or zirconium minerals showed high assays for hese two elements. The elements must have been

TABLE 1

RADIOACTIVITY OF SOME OF THE MINERALS IN THE DRILL CORE

Samples from the drill core	10^{-12} gm/gm Ra equivalent
lmenite and brookite	8.1
ample 1 (92% kaolinite) ..	9.6
" 2 (74% gibbsite) ...	13.1
" 3 (54% siderite) ...	8.6

resent in the form of adsorbed ions on one of the min- rals in the core. The writer believes that the uranium as introduced into the deposit in the form of the uranyl on, concentrated along with the titanates and zirconates hich were in the form of the above ions, and was ad- orbed on the aluminum mineral gibbsite, thus giving rise o the relatively high radioactivity found. The radio- activity of some of the samples from the drill core are listed in Table 1.

Miss Geraldine Sullivan, working on a program sponsored by the Geological Society of America at the Geochemical Laboratory of Massachusetts Institute of Technology, found that the average β-radioactivity for 233 shales was 9×10^{-12} gm/gm Ra equivalent. This figure can be used as a basis of comparison for the radioactivity of the samples listed in the above table. Almost all of the uranium is located in the sample containing a large amount of gibbsite, whereas the kaolinite specimen shows very little radioactivity.

[4] Could a process such as this account for the high radioctivity of certain carbonaceous shales or have something to o with the formation of oil by the polymerization of the ighly active carbon into hydrocarbons by radioactive rocesses?

References

1. FREDERICKSON, A. F. The mineralogy of a drill core of Arkansas bauxite. Sc.D. Thesis, Massachusetts Institute of Technology, 1947.
2. LATIMER, W. M. *The oxidation states of elements and their potentials in aqueous solutions.* New York: Prentice-Hall, 1938.
3. ROTHE, E. *Comp. rend.,* 1940, **221**, 753–756.

Penicillin Blood and Milk Concentrations in the Normal Cow Following Parenteral Administration

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The question of whether or not penicillin can be demonstrated in the milk of the dairy cow following parenteral administration has been undergoing considerable study. Seeley, *et al.* (*6*) tested milk of a normal cow for penicillin activity following intravenous administration. A total of 500,000 units was injected in two portions of 15 ml each about 1 min apart. No measureable amounts of penicillin were present when samples of milk were taken at frequent intervals for 24 hrs after dosing. Watts and McLeod (*7*) injected doses up to 1,000,000 units of penicillin intramuscularly into normal heifers and were unable to detect the drug in the milk. Barker and Dussault (*1*) treated a cow infected with mastitis streptococci with a total dosage of 2,681,000 units of penicillin, administered intramuscularly at 8-hr intervals over a period of 4 days and, on the basis of their results, stated that the lactating bovine mammary gland appears to be nonpermeable to penicillin.

When high, persisting blood concentrations were obtained following parenteral administration of Sulfamethazine in the dairy cow, significant amounts of the drug in the milk were demonstrated (*4*). When low blood levels were obtained after sulfathiazole administration and the

[1] The authors are indebted to Miss Frances L. Clapp and Miss Frances W. Bingham, of the Biological Testing Section, for penicillin assays and to H. Mundle and S. C. Griffith, of the Animal Industry Section, for aid in the conduct of the program.

drug was rapidly excreted, little or no drug was present in the milk (*5*). Therefore, it seemed likely that, if penicillin blood concentrations were sufficiently high and persistent, penicillin could be demonstrated in milk.

Two trials were instituted in normal cows, free of clinical mastitis on udder palpation and physical appearance of the milk on strip cup test. In Experiment I, one cow weighing 1,300 lbs and milking 55 lbs daily received a total dosage of 16,250,000 units of amorphous penicillin sodium. In Experiment II, one cow weighing 1,380 lbs and milking 35 lbs daily received a total of 17,250,000 units of crystalline penicillin G sodium. In each case, the penicillin was reconstituted in 1 cc of saline for each 200,000 units of penicillin. The drug was administered subcutaneously at the rate of 5,000 units/lb of body weight for the first dose and 2,500 units/lb for three subsequent doses at 6-hr intervals. Blood and milk samples were taken 15 min and 1 hr after the first dose, and at hourly intervals thereafter,

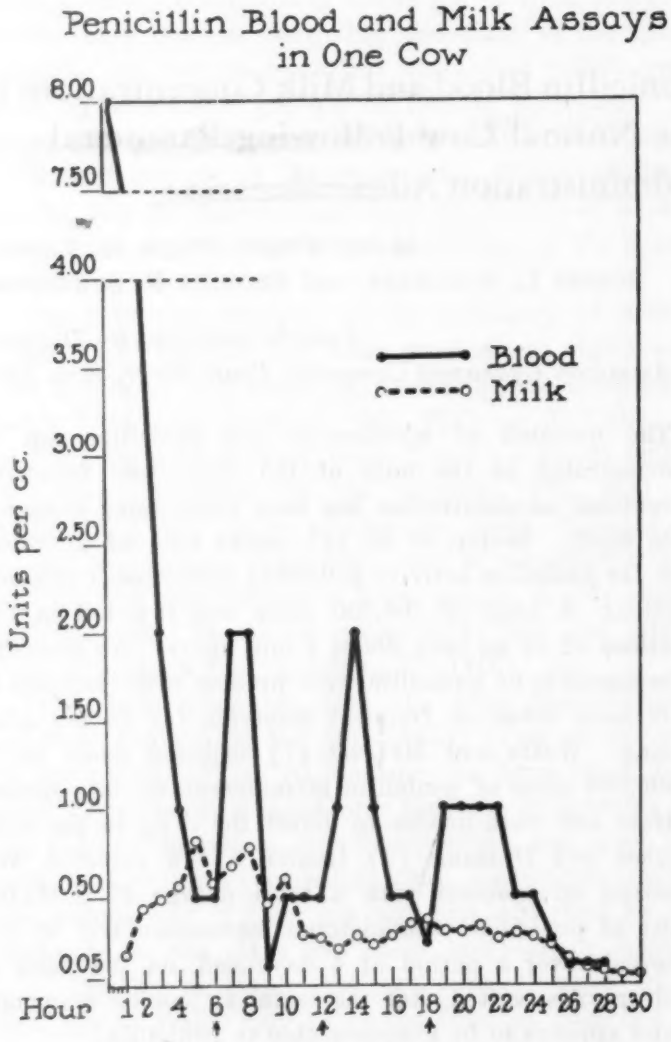

FIG. 1

through 30 hrs. The cows were completely milked out immediately before the first injection and at 12-hr intervals thereafter.

Blood serum assays were made according to the method of Chandler, Price, and Randall (*2*).

Milk assays were made by a modification of the *B. subtilis* cup-plate method of Foster and Woodruff (*3*). Filter paper discs (7 mm in diameter) were used instead of cups. Three cc of seeded agar was used, and 0.03 cc of the material to be tested was added to each disc. Plates were incubated at 39° C and were read after 4 hrs. The unitage of the test sample was determined by referring the diameter of zones of inhibition to a standard curve run daily on the specific body fluid, to which had been added standard penicillin in appropriate amounts.

Penicillin blood and milk concentrations obtained in Experiment I are shown in Fig. 1. A high level of 4 units/cc of blood was recorded 15 min after the first dose, and this decreased steadily to a low of 0.5 unit in about 5 hrs. After each subsequent dose, the level rose again, reaching high levels of 2 units, 2 units, and 1 unit at the 7th, 14th, and 19th hrs, respectively. At the 29th and 30th hrs, there was less than 0.03 unit, the lowest level that can be measured.

The milk level recorded 15 min after the first dose was less than 0.05 unit/cc. This rose steadily to a high of 0.84 unit/cc at the 5th hr, decreased slightly, and rose again after the second dose to 0.78 unit at the 8th hr. There was a very slight increase after each injection of penicillin. Although there was no measurable blood level after the 28th hr, a milk level of 0.06 unit was still present at 30 hrs.

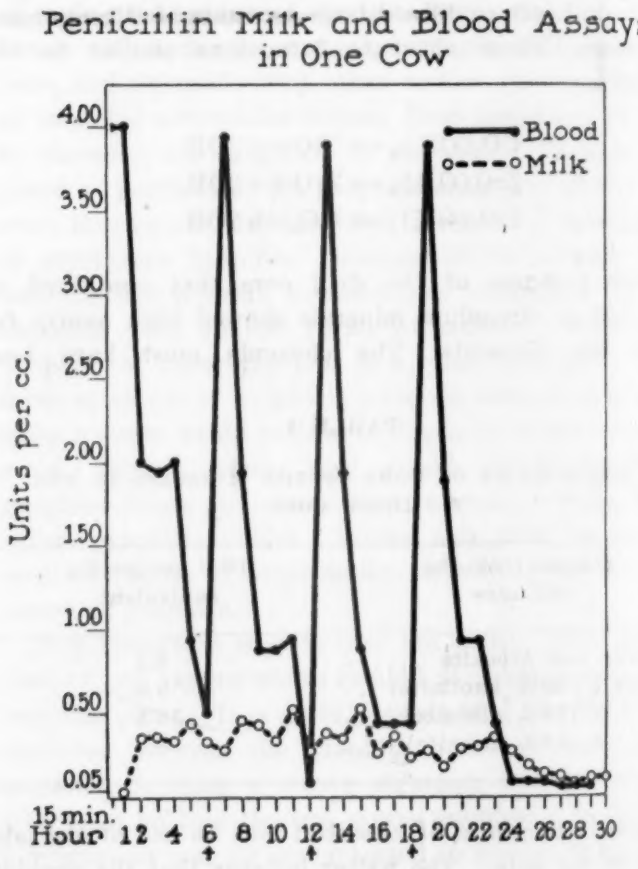

FIG. 2

Fig. 2 shows blood and milk concentrations obtained in Experiment II. A level of 4 units/cc of blood was recorded at 15 min and persisted through 1 hr. As in the first test, the blood concentrations decreased to approximately 0.5 unit or less within each 6-hr period. Following each subsequent dose, the levels rose to slightly less than the highest level recorded. There were no measurable amounts of the drug in the blood after 29

rs. The milk level curve was similar to that recorded the first experiment, with a high of 0.53 unit at 15 rs and 0.1 unit at 30 hrs.

The results obtained in these experiments indicate hat in the dairy cow, where there is rapid excretion of drug, measurable amounts of that drug in the milk re not likely to be found unless blood concentrations re high and persistent. The actual drug concentration the milk may not have great significance, but it dicates that the drug is present in the secreting tissues. he total dosage of an antibiotic or a sulfonamide used uring the course of treatment is relatively unimportant. lowever, the dose-time-weight relationship is important.

The purpose of this report is not to suggest the arenteral administration of penicillin for the treatment f mastitis. Penicillin can be localized in the udder by ntramammary infusions without as rapid loss as when he drug is administered parenterally, and higher concentrations can be achieved on smaller dosage and less requent administration. It is interesting to note, however, that there is diffusion of penicillin from blood o milk.

References

1. Barker, C. A. V., and Dussault, W. P. *Canad. J. comp. Med.*, 1945, **9**, 332.
2. Chandler, V. L., Price, C. W., and Randall, W. A. *Science*, 1945, **102**, 355.
3. Foster, J. W., and Woodruff, H. B. *J. Bact.*, 1944, **47**, 43.
4. Langer, P. H., Burkhart, R. L., Schroeder, C. R., and Welsh, M. *J. dairy Sci.*, 1948, **31**, 103.
5. Maclay, M. H., and Slavin, G. *Vet. Rec.*, 1947, **59**, 313.
6. Seeley, H. W., Anderson, E. O., Plastridge, W. N., and Pearson, P. *Science*, 1945, **102**, 44.
7. Watts, P. S., and McLeod, D. H. *J. comp. Path. Therap.*, 1946, **56**, 170.

Variations in Total Counts of P^{32} and I^{131} for Dishes of Different Atomic Number[1]

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In the measurement of radioactive isotopes in the laboratories throughout the country one finds variations as great as 50%. Some of the discrepancy may be due to the different materials of which the dishes used to measure the radiation are made. With this point in mind, the amount of radiation reflected from various materials was measured from given amounts of P^{32} and I^{131}.

Radioactive phosphorus emitting beta rays with a maximum energy of 1.7 Mev was evaporated to dryness on filter paper, Al, Cu, Sn, and Pb dishes, the amount of radioactive material being contained within a circle of about 1 cm in diameter. Measurements were made at a distance of 10 cm with a Geiger counter tube, the glass wall of which was 0.12 mm thick. The percentage reflection using paper as zero reflector increased with the atomic number of the various materials. Percentage reflection is defined as

$$100 \times \frac{I - I_0}{I_0},$$

where I = intensity in counts per minute of the primary beam and the reflected beam, and I_0 = intensity of the primary beam.

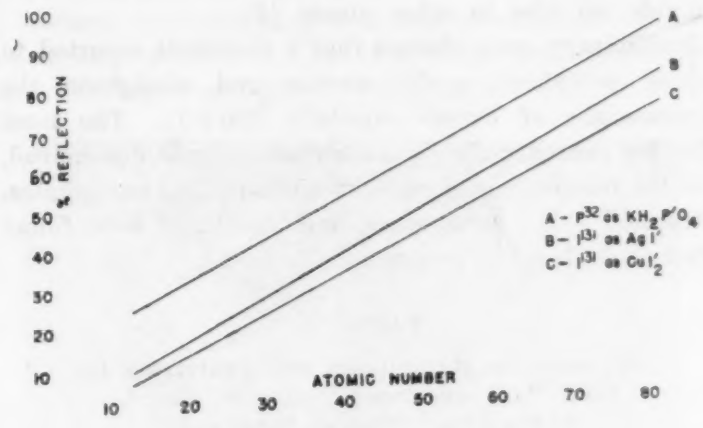

FIG. 1

Fig. 1 is a plot of the atomic number of the reflecting materials vs. percentage reflection. Measurements taken at 15 and 20 cm from the tube gave the same percentage reflection. Similar data at 10 cm from the tube were taken in a lead house, and the reflection ratios were the same as those in air.

Identical technique was followed for I^{131}, which emits beta rays with a maximum energy of 0.7 Mev and gamma rays with a maximum energy of 0.4 Mev.

Since I^{131} sublimes and is difficult to handle, it was first bound as silver iodide by the use of $NaHSO_3$ and $AgNO_3$. Other samples were bound as cupric iodide by the use of $NaHSO_3$ and cupric acetate. Measurements of these two salts showed a variation of only about 6% and suggest that I^{131} may be measured in either form, since there is no appreciable scatter from the copper or silver atoms or from the residual nonradioactive salts.

The data obtained by the use of AgI and CuI_2 in dishes of different materials are also presented in Fig. 1. Both of these plots fall below that for P^{32}, which fact is in reasonable agreement with the data published by Zumwalt (*1*).

The results obtained from these experiments show that the percentage reflection from the various dishes bears linear relation to the atomic number of the reflecting material when filter paper is used as a nonreflecting material. From this work it may be concluded that the amount of radioactivity as reported will vary considerably according to the type of dish used.

Reference

1. Zumwalt, L. Absolute beta counting using end-window Geiger-Müller counter tubes. (Clinton Laboratories.)

[1] Supported in part by N5,ORI–76 Project, Order VII, NR-171-105.

The P^{32} and I^{131} used in this investigation were supplied by Clinton Laboratories and obtained on allocation from the U. S. Atomic Energy Commission.

[2] The authors wish to thank Charles K. Spalding and Kathryn H. Haley for their assistance in preparing this paper.

Modification of Mitosis by Chemicals[1]

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The mitotic chromosomes of guayule (*Parthenium argentatum*) are difficult to study because they are small, numerous, and tangled. Treatment with colchicine, found advantageous with *Phlox* (*1*), failed to facilitate the study of guayule chromosomes. It was found however, that *p*-dichlorobenzene could be used in a technic which permits precise chromosome studies not only in guayule but also in other plants (*2*).

Preliminary work showed that 8 chemicals reported to induce polyploidy could shorten and straighten the chromosomes of *Crepis capillaris* (2n = 6). The most effective concentration of each chemical was determined, and the relative percentages of diploid (2X) metaphases, tetraploid (4X) metaphases, and anaphases were found after each chemical treatment (Table 1).

TABLE 1

PER CENT OF METAPHASES AND ANAPHASES IN ROOT TIPS OF *Crepis capillaris* (2n = 6) AFTER 2-HR CHEMICAL TREATMENTS

Chemical	Concentration of chemical*	Mitotic divisions†		
		Metaphases		Anaphases
		2x	4x	
Acenaphthene	1.00	83	4	13
Chloral hydrate	0.10%	76	13	11
Chloroform-water	0.10	70	4	26
Colchicine	0.20%	98	2	0
Mercuric chloride	0.00005	80	1.5	18.5
p-Dichlorobenzene	1.00	89	6	5
Sanguinarine nitrate	0.005	78	4	18
Sulfanilamide	1.00	96	4	0

* Proportion of a saturated solution in distilled water at room temperature, except concentrations given in %.

† Forty mitotic divisions in each of 10 root tips, or 400 mitotic divisions, classified for each chemical treatment.

The chloral hydrate treatment produced far more tetraploid metaphases than did the other chemical treatments; apparently this drug allowed sister chromatids to separate from each other in spite of the absence of a normal, anaphase-producing spindle. The chloral hydrate and chloroform-water treatments sometimes caused the sister chromatids of some, but not all, of the chromosomes to separate from each other. This gave chromosome numbers intermediate between the diploid and tetraploid numbers; these divisions were classed as tetraploid.

No anaphases were found after the colchicine and sulfanilamide treatments. Perhaps sulfanilamide could be used to induce polyploidy during the current shortage of colchicine. The chloroform-water treatment gave a high percentage of anaphases. There are no comparable data on the percentage of anaphases without treatment.

Some late prophase chromosomes showed distinct minor coils after the treatments with chloroform-water, colchicine, *p*-dichlorobenzene, and sulfanilamide. Sister telophase nuclei were sometimes connected by chromatin bridges after the chloral hydrate, colchicine, and mercuric chloride treatments. Some of these bridges were formed by lagging chromosomes, while others may have been due to chromosome breakage and recombination.

[1] Studies leading to this paper were made while the writer was employed by the Special Guayule Research Project, Bureau of Plant Industry, Soils, and Agricultural Engineering, Agricultural Research Administration, USDA.

References

1. MEYER, JAMES R. *Stain Technol.*, 1943, **18**, 53.
2. MEYER, JAMES R. *Stain Technol.*, 1945, **20**, 121.

On the Nature of the Interaction Between Actomyosin and ATP

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GERALD OSTER

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There is at present considerable interest in the nature of the interaction between adenosine triphosphate (ATP) and actomyosin (Weber's myosin). This interest originates in experiments which Engelhardt, *et al.* (*5*) performed on actomyosin threads manufactured by squirting a thin stream of concentrated protein solution into water. These investigators found that ATP induces an increase in tensile strength of actomyosin threads made in this manner. Subsequently, Szent-Györgyi and his collaborators (*8*) have reported that threads of actomyosin which are floating freely in water "contract" upon treatment with ATP. Furthermore, Buchthal (*2*) has emphasized the possible importance of the ATP-actomyosin interaction in the living muscle cell. He maintains that ATP can produce a contraction in a single muscle fiber. This contraction is associated with an action potential and is accompanied by a reversible decrease in birefringence of the fiber. Indeed, Buchthal (*1*) has stated that the "breakdown of ATP is the reaction nearest in time to the physical process of contraction."

Unfortunately, agreement is not general on the nature of the effect of ATP on the actomyosin molecule. Thus in a study of actomyosin dispersed in KCl solution, rather than in the form of threads, Needham and co-workers (*4*) observed that both ATP and high concentrations of KCl bring about a drop in viscosity and flow birefringence of the protein solution. They concluded that these changes are the result of a coiling up of the actomyosin molecule. Contrariwise, Szent-Györgyi considered quite similar data to indicate that both ATP and high KCl concentrations

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ct a dissociation of the dispersed actomyosin molecules
o actin and myosin.

induction of coiling in actomyosin by ATP is con-
ent with the notion that the ATP-actomyosin interplay
of fundamental importance in muscular contraction.
wever, if ATP produces dissociation in actomyosin, it
not easy to understand the role that this interaction
ght play in contraction of the muscle cell.

To obtain information of possible value for a clearer
derstanding of the ATP and KCl effect, we have under-
en the light-scattering and electron microscope studies
cribed here in a preliminary report.

The actomyosin used in our experiments has been pre-
ed by a method slightly modified from that of Green-
n and Edsall (*6*). The preparation was purified by
racentrifugation at 28,000 rpm.

The light-scattering measurements were made with a
ple apparatus which employs the 546-mμ line of a mer-
y vapor lamp as light source and a photomultiplier
e for registering intensities of scattered light. We
e determined the intensities of light scattered in the
izontal plane at angles of 45° and 135° with a beam
light transmitted through a 1% solution of actomyosin
.5 molar KCl and 0.09 molar KH_2PO_4–K_2HPO_4 buffer
pH 6.8. In 10 observations on three preparations of
omyosin, an average value of 3.4 was obtained for the
io of the forward to backward scattering at the angles
tioned.

Debye (*4*) has pointed out that measurements of this
o yield information concerning the size, shape, and
avior of macromolecules comparable in size with the
e length of light. Furthermore, Oster (*7*) has deter-
ed the limiting values of the ratio to be expected for
romolecules which are in the form of spheres, random
ls, or stiff rods. In the light of Oster's calculations for
angles used here, the value of 3.4 which we have found
actomyosin indicates that this protein has a configura-
n intermediate to that of a stiff rod or random coil;
t is, the actomyosin particles in 0.5 molar KCl at
6.8 are slightly coiled.

After addition of ATP in quantity sufficient to make
final concentration 1% in a solution of actomyosin
.5 molar KCl and buffer at pH 6.8, it was found that
ratio had increased to 4.7. This was observed in 5
eriments on two preparations of actomyosin. On the
is of the theory of light scattering (see *7*) one should
ect the ratio to decrease if the actomyosin were dis-
iated by ATP. However, the increase in ratio we have
erved is entirely consistent with an increase in coil-
of the actomyosin.

No change in pH of the actomyosin solution after addi-
n of ATP was detectable as measured by glass elec-
de. Tenfold dilution of the ATP-actomyosin solution
th 0.5 molar KCl did not alter the ratio of 4.7, nor was
re a change in light transmission of the actomyosin
tion after addition of ATP. The transmission was
asured in a Klett-Summerson colorimeter using a blue
er. The latter finding may be interpreted as indicating
t the change in ratio is not the result of aggregation
coagulation of the actomyosin.

Addition of KCl to actomyosin solution over a concentration range of 0.5 to 2 molar KCl failed to alter the ratio at the previously stated angles. This result, obtained in 5 experiments done on two preparations, constitutes good evidence that the actomyosin does not dissociate at higher concentrations of KCl. It is, rather, an indication that there is no change in the size or shape of the protein as a result of increasing the concentration of KCl. Thus, the drop in viscosity of actomyosin solution observed at high KCl concentrations demands an explanation different from those previously offered. It is conceivable that the decrease in viscosity is related to an electroviscous effect and is associated with the adsorption of potassium by actomyosin.

Electron micrographs demonstrate an effect of ATP on actomyosin which is consistent with the preceding interpretation based on light-scattering data.

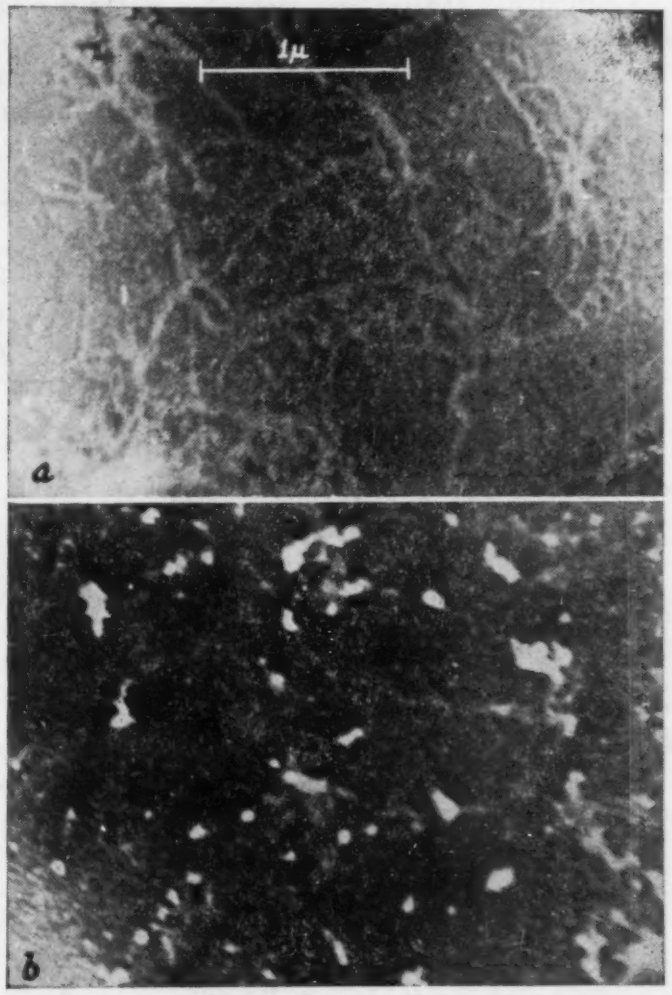

FIG. 1

Samples of untreated actomyosin were prepared by placing a drop of 0.01% actomyosin solution in 0.5 molar KCl on a collodion film supported by a copper screen. The sample was allowed to dry and was washed with distilled water to remove readily soluble salts. The specimen was then gold shadow-cast by the method of Williams and Wyckoff (*9*) to enhance photographic contrast. Fig. 1a is a representative picture of such a sample taken in an RCA console model electron microscope. The typical entangled, fibrillar structure of actomyosin is illustrated, along with the characteristically wide distribution of particle lengths.

Similar samples were then prepared from solutions of 0.01% actomyosin in 0.5 molar KCl to which ATP had been added in sufficient quantity to make its final concentration 0.01%. Fig. 1b is a picture of such an ATP-treated specimen. As can be seen in the figure, the bulk of the elongated fibrils of actomyosin have been changed into shortened, thickened irregularly shaped forms. They are of different sizes, as is to be expected from the wide distribution of particle size in the untreated specimen.

It was impossible to study the effect of varying KCl concentrations on actomyosin in the electron microscope. The changes in salt concentration which occur in the preparation of the sample make it impossible to know with any accuracy the effective KCl concentration.

Thus, we have obtained evidence from light-scattering observations which indicates that actomyosin dispersed in KCl solution has the configuration of a slightly coiled particle. Increasing the concentration of KCl does not affect this configuration. On the other hand, as shown by light-scattering data reinforced by electron micrographs, ATP increases the degree of coiling of ac myosin, an effect which is compatible with a fundame role in muscular contraction for this nucleotide-pro interaction. Further studies on both the ATP and K effects are in progress.

References

1. Buchthal, F. *Annu. Rev. Physiol.*, 1947, **9**, 119–14
2. Buchthal, F., Deutsch, A., and Knappeis, G. G. *Physiol. Scand.*, 1946, **11**, 325–334.
3. Dainty, M., Kleinzeller, A., Lawrence, A. S. C., Ni ham, J., Needham, D. M., and Shen, S. C. *J. Physiol.*, 1944, **27**, 355–399.
4. Debye, P. Lecture given at the Polytechnic Institut Brooklyn, November 25, 1944; *J. phys. coll. Ch* 1947, **51**, 18.
5. Engelhardt, V. A., Lyubimova, M. N., and Meir R. A. *C. R. Acad. Sci. U.R.S.S.*, 1941, **30**, 644.
6. Greenstein, J. P., and Edsall, J. T. *J. biol. Ch* 1940, **133**, 393–408.
7. Oster, G. *Chem. Rev.*, in press.
8. Szent-Györgyi, A. *Chemistry of muscular contrac* New York: Academic Press, 1947.
9. Williams, R. L., and Wyckoff, R. W. G. *J. appl. Ph* 1944, **15**, 716.

IN THE LABORATORY

Modification of the Kardos Shadow Experiment for Demonstrations of Color Mixing

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In an experiment first described by Kardos (*2*), a small disc is suspended in the center of a hole in a screen. The screen is illuminated from a strong source, but an object is interposed to cast a shadow on the disc, so that the edges of the shadow fall within the hole around the disc. With this arrangement, and using a light gray screen and disc, the latter appears to be black, or very dark gray, even though the observer can see the source of illumination and the shadow caster and, seated slightly to one side, can observe that the shape of the shadow falling on the wall to the rear of the screen is not of the same shape as the disc. The illusion is so compelling that even continued observations, alternately of the normal disc color without the shadow and of the disc in the shadow, do not serve in any way to decrease its strength. Descriptions of this and similar experiments may also be found in Brunswik (*1*) and Woodworth (*3*).

A different, but equally striking effect, can be produced by having the room in semidarkness and illuminating the disc alone with a brilliant source. In this case the disc appears to be a source of light itself, much as the moon seems to be. It was while investigating the effects of colored light on such a disc that the writer found the Kardos apparatus to be a most excellent device for de onstrating color mixing.

The screen used was of light gray cardboard, 35″ l and 23″ high. From the center a circular hole 8″ diameter was cut. Within this hole a 4″ disc was s pended by means of thin black threads, crossed to s pend the disc steadily and fastened to the rear of t and screen with cellulose tape. (In the Kardos exp ment, the disc is of the same material as the screen, for color mixing a white disc may be used if desir For illumination, two or more strong, narrow beams light and suitable colored filters were used. With screen about 4′ from the rear wall and the obser seated slightly to one side so that they can see where edges of each light beam strike the wall, it is possible examine the results of the mixture on the disc wi being able to see an "analysis" of the colors used the rear wall.

With this apparatus and good red and green fil it is possible to produce a powerful, well-saturated yel on the disc, quite unlike the dirty yellow usually achie with a color wheel or the weak, streaky effect usu obtained with lights observed through milk glass. W blue and yellow filters or three sources—red, green, blue, a bright white is easily achieved. Relative bri nesses can be regulated by polaroid filters, episcotis or distance of source, whichever may be convenient.

In addition to color mixing, a great variety of dem strations of afterimages, simultaneous contrast, and duction of the complementary color in contrast shad may be performed with this apparatus. For exam

e screen may be flooded with one color, with a shadow aster between the disc and this source, while a different olor is used to illuminate the disc alone.

The advantages of this device over others previously ried by the writer are numerous. First of all, the stuents can see everything that is done; there are no conealed light sources, no elaborate equipment. An equally portant feature is the fact that the colors seem to be in the object viewed and not merely cast upon the wall r diffused from behind through milk glass. There are o fringes of monochromatic light, which often serve to educe the vividness of the mixture. It is true that such ringes may be removed by observation through a reduction screen, but such a procedure always tends to destroy e appearance of surface color to a considerable degree. A further advantage is the speed with which variations n the demonstrations may be set up; one of the most nnoying things about color wheels is their inefficiency in this regard. Should it be desired to move the apparatus from room to room, the screen could easily be given a ooden frame so that it could be moved about and set on lassroom desks. Portability of the light sources would epend upon the type available. Finally, this apparatus affords a negligible storage problem when not in use.

References

1. Brunswik, E. *Experimentelle Psychologie.* Vienna: Julius Springer, 1935. P. 96.
2. Kardos, L. *Z. Psychol.*, Ergänzungsb. 23, 1934.
3. Woodworth, R. S. *Experimental psychology.* New York: Holt, 1938. Pp. 611–614.

Recent Procedures for the Study of Three-dimensional Shapes of Resting Cells, and a New Method for the Shape Study of Cells in Division

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Since detailed studies of three-dimensional shapes of ls in tissues are relatively recent, standardized techques have not as yet been adopted. The first investigaons (*2*) utilized essentially Born's wax plate method. this, individual cells were reconstructed from serial tions and examined under the compound microscope, sections being modeled consecutively in sheets of wax. bsequently a wax impregnation technique was emyed (*5*), in which masses of cells were infiltrated with hard wax. The wax casts of individual cells were then parated, studied under a binocular dissecting micrope, and modeled face by face.

In later work cells were analyzed in tissues, without tioning or separation. In some cases the tissues were ed, stained either with safranin or Delafield's hemaylin, cleared in xylol, and mounted in mineral oil. ey were then studied under the binocular dissecting miscope. In another instance (*1*) living cells were stained lightly with neutral red, mounted in water, and studied similarly. All of these investigations have dealt with relatively large and mature cells.

Although the binocular dissecting microscope is well adapted to three-dimensional cell shape studies, the possibility of using it is eliminated in some of the most fundamental parts of the plant, such as the apical meristems, because of insufficient magnification. In the study of the three-dimensional shapes of minute cells, two different techniques have been used. In the first, the Duchartre-Lewis method (*3*, *4*), longitudinal and transverse sections of the tissues were made; from these the number of faces, in section, could be determined under the compound microscope and the average number of faces per cell computed. While this method is helpful in determining the average number of faces, it has obvious limitations: it works best in tissues with the cells regularly arranged, it does not tell the precise number of faces on any individual cell, and it gives no information on the kinds of faces (whether they are quadrilateral, pentagonal, etc.). In the other investigation of minute cells (*6*), dealing with the apical meristem, stem tips were cleared in lactic acid (*8*), stained in Delafield's hematoxylin, and mounted "in toto" in balsam. They were then studied under the compound microscope.

Finally, in investigations now under way, the three-dimensional shapes of dividing cells in telophase have been analyzed. More specifically, the problem to be solved was determination of the original shape of the individual cells before division and of the two daughter cells directly after division, in order to make comparisons of the shape changes involved in the process of mitosis. To accomplish this it was necessary to see clearly the nuclei, both resting and dividing, the spindle fibers and cell plate, and the original walls of the cells. However, since the walls of several superimposed layers of cells had to be identifiable, merely by focusing, they could be stained only lightly. Furthermore, the dense cytoplasmic contents of the meristematic cells had to be nearly or quite transparent so that the components to be studied would not be obscured. To achieve the desired results the preparations were stained with Feulgen, ruthenium red, and orange G. The procedure was as follows:

Stem tips of *Anacharis densa* (Elodea) were dissected out, killed in Craf fixative, embedded, and sectioned at 25 μ or thicker. They were then stained with the Feulgen technique as outlined by de Tomasi (*9*), except that they were hydrolyzed longer (30 min) in N HCl and stained in decolorized fuchsin for 24 hrs. After being rinsed in distilled water the slides were put into a strong aqueous ruthenium red solution for 30 min, quickly rinsed again in distilled water, and run as rapidly as possible into absolute alcohol. They were then stained for about 1½ min in orange G in absolute alcohol and clove oil, rinsed in clove oil, put into xylol, and mounted in neutral balsam.

By this procedure the chromatic figures of the dividing nuclei were stained deep purple, while the color of the resting nuclei was much less intense. The middle lamella was darkened with ruthenium red, while the spindle fibers and cell plate were stained, to some extent with orange G.

The cellulose walls and protoplasm were not deeply colored, so that the shapes of several superimposed layers of cells could be determined effectively.

The slides were studied under oil immersion with a binocular monobjective Zeiss microscope, using Köhler illumination (7) and green and orange Wratten filters. The preparations are beautiful. The data obtained will be published elsewhere.

References

1. Dodd, J. D. *Amer. J. Bot.*, 1944, **31**, 120.
2. Lewis, F. T. *Proc. Amer. Acad. Arts Sci.*, 1923, **58**, 537.
3. Lewis, F. T. *Science*, 1928, **68**, 625.
4. Marvin, J. W. *Amer. J. Bot.*, 1939, **26**, 487.
5. Marvin, J. W., and Matzke, E. B. *Amer. J. Bot.*, 1939, **26**, 101.
6. Matzke, E. B. *Amer. J. Bot.*, 1948, **35**, 323.
7. Muñoz, F. J., and Charipper, H. A. *The microscope and its use.* New York: Chemical Publishing Company, 1943. P. 69.
8. Simpson, J. L. S. *Stain Technol.*, 1929, **4**, 131.
9. de Tomasi, J. A. *Stain Technol.*, 1936, **11**, 137.

An Improved Moist Chamber Slide for Use in Micromanipulation

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The moist chamber slide to be described here is essentially a modification of that described by Chambers and Kopac (*1*). Although the chamber considered here is designed for use with the Chambers micromanipulator, its basic construction features may be adapted readily to any chamber type according to individual preference or need (*1*).

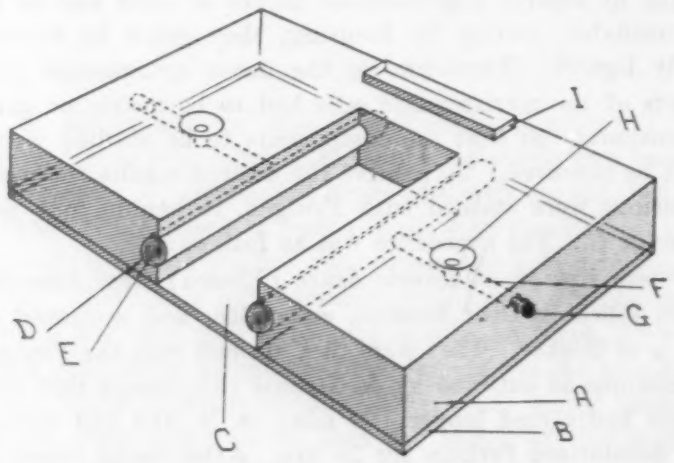

Fig. 1

The moist chamber slide consists primarily of a sheet of plastic (Fig. 1A), 2″ × 3″ × ⅛″ thick, cemented by means of Clarite to a standard 1-mm-thick 2″ × 3″ glass microscope slide (B). A centered, rectangular-shaped notch cut in the front edge of the plastic sheet constitutes the moist chamber proper (C). A rounded groove (Figs. 1D, 2) running the length of each side wall of the moist chamber holds a small roll of filter paper (E). Small drilled channels (F) extending from each edge of the plastic sheet and opening into their respective grooves in the side walls of the moist chamber (D) also hold small rolls of filter paper. The outside ends of these channels are closed by means of small stoppers (G). Each lateral channel (F) opens onto the top surface of the plastic sheet through a vertical funnel-shaped channel (Figs. 1H, 2). A small plastic strip welded on the top surface near the rear end of the moist chamber constitutes a coverslip stop (I).

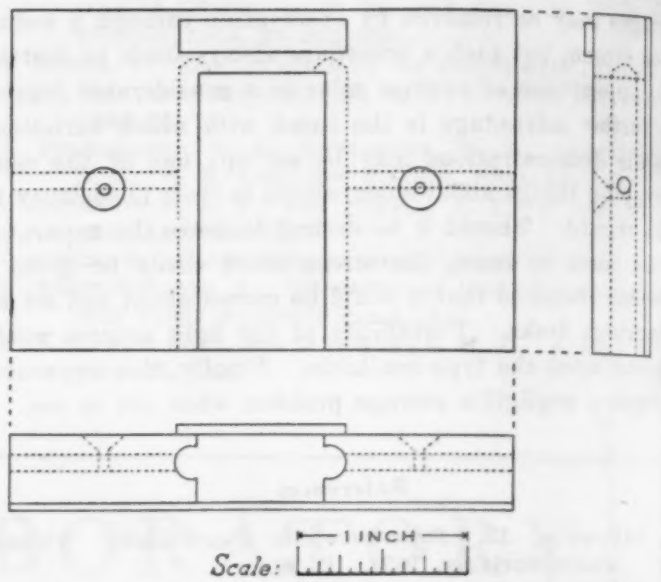

Fig. 2

In ordinary use, the chamber is moistened simply by the periodic addition of drops of water to the funnel-shaped channels. The filter paper rolls, by capillarity, quickly conduct the water directly to the critical area of the moist chamber. If one is studying simple qualitative influences of diverse water-soluble gases on the cells in the hanging drop, aqueous solutions of such gases also are introduced into the moist chamber in the same way, but the funnel-shaped channels are covered in between times by small coverslips sealed down with vaseline to prevent the diffusion of gas from these points. This method of keeping the chamber moist has several distinct advantages over the standard moist chamber slide. It precludes the chance disarrangement of the manipulation needles when in use. Further, it provides a measurable control of the relative amount of moisture within the chamber when this is essential. It dispenses with the interferences so commonly occasioned by filter paper strips within the chamber and excess water on its floor.

The detailed measurements necessary for the construction of this moist chamber slide may be obtained by applying the 1″ scale to the construction drawings (Fig. 2). The various properties of sheet plastic make it a material of choice and one very easily worked. Its uniform thickness virtually eliminates the necessary but usually laborious task of leveling the walls of the chamber.

Reference

1. Chambers, R., and Kopac, M. J. In *Microscopical technique.* C. E. McClung. (Ed.) New York: Paul B. Hoeber, 1937. Pp. 62–109.

[1] I would like to extend my thanks to E. F. Hiser, of our Medical Art Department, for the preparation of the illustrations.